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14. ABSTRACT
The 1999 Air Force Scientific Advisory Board (SAB) Summer Study focused on potential future environments that may involve the Air Force in Operations Other Than Conventional Warfare (OOTCW). The SAB was asked to provide technology options that could leverage the application of aerospace power in such operations.The outcome of the study was a set of technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment. The team was to look at concepts, ideas and technologies that would allow United States forces to prevail while minimizing the number of airmen and ground troops that would have to be put at risk in OOTCW.The study considered the past and potential future OOTCW environments and considered operations from humanitarian relief (HUMRO), noncombatant evacuation (NEO), peacekeeping, and no-fly zone maintenance, through regional conflict. The upper range of operations for the study, regional conflict, was understood to be just short of the very significant level of conflict encountered in Kosovo. While the study did not in general emphasize the lower-intensity operations (HUMRO and NEO), it did become clear early on that such ?peacetime? operations have significant operational tempo impacts. The study attempted to define these impacts and to offer mitigation ideas.

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in
Operations Other Than Conventional War

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Foreword

This volume summarizes the deliberations and conclusions of the 1999 Air Force Scientific Advisory Board (SAB) Summer Study, “Technology Options to Leverage Aerospace Power in Operations Other Than Conventional War.” In this study, we considered the potential environments of such operations and developed recommendations for improving Air Force involvement and response. It was an iterative process involving government and industry experts.

The SAB wishes to thank the many individuals who contributed to the deliberations and the report. In addition to SAB members, many ad hoc members devoted their precious time. Industry assisted, and the Air Force major commands were extremely helpful. Many other DoD and non-DoD agencies also provided significant input and assistance.

The Air Force Academy technical writers and panel executive officers provided invaluable assistance to the study, both in coordinating our efforts and in providing substantive input and advice on the conduct of the study and the final report.

The study committee would also like to give special recognition to the SAB Secretariat and support staff, in particular to Major Doug Amon, whose limitless energy and dedication were an inspiration to all of us, and to the ANSER support team led by Dr. Robert Finn and technical editor Ms. Kristin Lynch.

Finally, this report reflects the collective judgment of the SAB and hence is not to be viewed as the official position of the U.S. Air Force.

Mr. Tom McMahan	Dr. Peter R. Worch
Study Chair	Deputy Study Chair

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Chapter 1
Introduction and Executive Summary

1.0 Introduction

The 1999 Air Force Scientific Advisory Board (SAB) Summer Study focused on potential future environments that may involve the Air Force in operations other than conventional war (OOTCW). (NOTE: The term OOTCW if for the purpose of this study only.) The SAB was asked to provide technology options that could leverage the application of aerospace power in such operations. The terms of reference for the study can be found in Appendix A to Volume 2. Study guidance asked the group to undertake the following major tasks:

- Review operations conducted in the past decade
  - Identify successes and limitations
  - Identify ideas to enable aerospace forces to improve outcomes
- Posit future situations that represent “less-traditional” operations
  - Assess the capabilities of programmed forces
  - Identify deficiencies
- Survey the technology options available and suggest the technologies that should be pursued
  - Near term—examine current operational art
  - Farther term—identify technology options
  - Consider the effects of lethal and non-lethal weapons
- Identify tests or demonstrations necessary for evaluating the study recommendations; recommend appropriate Air Force involvement

The desired outcome of the study was a set of technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment. The team was to look at concepts, ideas, and technologies that would allow U.S. forces to prevail while minimizing the number of aircrew and ground troops that would have to be put at risk in OOTCW. The Air Force sponsors offered operations such as Mogadishu, Somalia (OPERATION RESTORE HOPE), and the continuing no-fly-zone operations in Southwest Asia as historical examples for us to study and by which to measure the potential of our recommendations.

1.1 Executive Summary

The study considered the past and potential future OOTCW environments, including humanitarian relief operations (HUMROs), noncombatant evacuation operations (NEOs), peacekeeping, no-fly-zone maintenance, and regional conflict operations. The study’s upper range—regional conflict—was understood to be just short of the very significant level of conflict encountered in Kosovo. While the study did not emphasize the lower-intensity operations (HUMRO and NEO), it did become clear early on that such “peacetime” operations have significant operational tempo (OPTEMPO) impacts. The study attempted to define these impacts and to offer mitigation ideas.

The OOTCW environment as defined by the study has the following attributes:

- Diversity of operating environments

- Inability to predict location, geography, and conditions for the next operation
- High likelihood of urban operations
- Extremely high sensitivity to collateral damage
- Need to sense, target, and identify individuals and small groups
- Multinational coalitions
- Potential for a very long duration of "hostilities" with large excursions of intensity

Historical data show that the relative probability of occurrence of operations is highest at the lowest-intensity end of the scale and decreases toward the major theater war (MTW) end of the spectrum. While this is a comforting statistic, the study shows that the frequency of relatively low-intensity, low-risk operations could have the effect of wearing heavily on aerospace forces because of OPTEMPO issues. This could result in an increased risk to the successful execution of aerospace operations in escalated OOTCW and MTW scenarios. As a result, the study team focused its energy on finding ways to reduce these risks.

Two ways of thinking about the application of aerospace power were very helpful to the conduct of the study—Global Engagement Operations (GEO) and effects-based targeting. (NOTE: During Corona 1999, the term GEO was altered to refer to Global Expeditionary Operations vice Global Engagement Operations.) GEO is being used by the Air Force to prepare for the next Quadrennial Defense Review. The study group felt that presenting recommendations in the context of GEO would allow the Air Force leadership to visualize quickly the potential feasibility and impact of those recommendations. A brief description of GEO can be found in Chapter 2 of this volume. A complete description is available on CD-ROM and may be requested from the Air Force Scientific Advisory Board Secretariat. Chapter 11 of Volume 1 displays a summary of recommendations showing how each relates to the phases and elements of GEO.

Effects-based targeting involves thinking about the application of aerospace power in terms other than the number of sorties, bombs, and routes desired. It encourages the Joint Forces Commander to think of aerospace power in terms of the effects desired, leaving it to the Joint Force Air Component Commander staff to translate those desired effects into the specifics of air tasking orders. The study group was encouraged from the outset to think in these terms, as lethal and non-lethal weapons were considered regarding OOTCW applications. This directed the group's thinking considering the precision of targeting information and weapons delivery and the yield, or effect, of the weapons.

The study team of 68 members spent more than 12,000 person-hours conducting the Summer Study, visiting more than 71 organizations during 33 major trips. Visits to all levels of Air Force activities took place—from the commanders of major air commands to staff officers and personnel on the flight line. The other Services were included as well, and each provided advisory members to serve on the study. Briefings were received from the senior levels of the U.S. Special Operations Command, Department of State, National Security Agency, Central Intelligence Agency, Federal Emergency Management Agency, and other agencies. The result was a wealth of background data and understanding of Government-wide issues and capabilities involving OOTCW.

1.2 Overarching Recommendations

The study found seven "overarching" recommendations involving overall Air Force policy or broad areas of technology or capability:

- The Global Positioning System is critical to OOTCW. As recommended by the SAB since 1993, the Air Force should solve the accuracy and vulnerability problems.

- To successfully transition to an Expeditionary Aerospace Force (EAF), the Air Force should broaden its focus to encompass training, communications, deployment, weapons, and forward support, in addition to the recommendations of the 1997 SAB Aerospace Expeditionary Force (AEF) Study and this study.
- The Air Force should develop a comprehensive vision and strategy that takes into full account all potential roles of non-lethal weapons, including "variable effect" and delivery from the air and/or space. Integration into the overall response continuum is essential.
- The Air Force should ensure that the Rapid Response Process remains viable to define, develop, and deploy time-sensitive systems identified by the commander in chief as critical to combat operations, including OOTCW.
- The Air Force should ensure that the development of strategies, concepts, techniques for offensive and defensive information warfare are closely coupled for maximum effectiveness.
- The critical requirement for information superiority suggests increased emphasis on defensive information warfare, including assessment of detected threats and development of responses.
- The Air Force should ensure that discretionary funds are available to laboratory managers to focus on promising technologies and revolutionary capabilities. Industry-independent research and development managers should be encouraged to do the same.

1.3 Major Recommendations

The study resulted in 60 separate specifically defined and executable recommendations. Twelve are considered "major" recommendations with clearly identified actions and are summarized below. In addition, the study found seven recommendations involving overall Air Force policy or broad areas of technology or capability. These too are summarized below and detailed in Chapter 3. The remaining recommendations are covered in the separate panel sections of this volume. The major recommendations are grouped in the following categories:

- **Enable persistent intelligence, surveillance, and reconnaissance (ISR).** Recommendations that allow the flexible, scalable, long-dwell ISR that OOTCW demand, while reducing the OPTEMPO impacts on the forces.
- **Develop and integrate ISR and dynamic planning.** Recommendations that will improve or develop the integrated tools needed to apply ISR and battle management and planning in the effects-based operations environment.
- **Develop a spectrum of tailored weapons effects.** Recommendations that will improve the lethal and non-lethal applications of aerospace power.
- **Maintain readiness and presence within OPTEMPO constraints.** Recommendations that will reduce the impact on airlift, logistics, and training systems.

While there is a relatively large number of recommendations, it should not be concluded that the Air Force must undertake a major overhaul to conduct OOTCW. To the contrary, the Summer Study concludes that the majority of the recommendations are applicable across the spectrum of operations. The recommendations are intended to build on current force structure and policy in ways that enhance the ability to conduct OOTCW while avoiding unique solutions applicable only to OOTCW.

Also, several of the recommendations are essentially in common with the results of the SAB's other major 1999 study effort on the Joint Battlespace InfoSphere (JBI). The Summer Study recommendations in this category offer specific, potential uses for the JBI and are identified as JBI-related for cross-reference to that study.

The following is a brief summary of the major recommendations.

Enable Persistent ISR

Recommendation 1: Expand ISR capabilities for unmanned aerial vehicles (UAVs) to augment long-duration data collection. Start with air surveillance on Global Hawk. This will provide a robust capability to supplement ISR functions currently performed by the "low-density/high-demand" platforms and will significantly reduce stress on current platforms and personnel while performing the same missions. This is particularly useful for Shape phase indication and warning and Reshape phase for no-fly-zone enforcement.

Recommendation 2: Develop sensors and air-launched vehicles for ISR, targeting, and battle damage assessment (BDA) of ground targets. It is essential that the Air Force provide long-duration, low-cost ISR, targeting, and BDA; monitoring and defeat of new threats; and shaping of the battlefield through knowledge and psychological operations. Develop a program to integrate newly developed low-cost sensors and air-launched and airdropped deployment vehicle technologies such as UAVs; ultra-precision (< 1 meter), robust navigation; high-g, low-power electronics; ultra-miniature guidance systems; micro sensors; and robotics.

Develop and Integrate ISR and Dynamic Planning

Recommendation 3: Implement a force management capability for the EAF and for OOTCW that supports the EAF in the application of aerospace power to OOTCW and enables dynamic effects-based planning, execution, and assessment, including strike, airlift, and training. Feedback consists of dynamic battle control, action or BDA, and effects assessment. Continue selective deployment of the Theater Battle Management Core System (TBMCS), but immediately begin preparation of an operational architecture to ensure that TBMCS meets the needs of the EAF in OOTCW. Include logistics, training, and lift aspects. Assess the proper course of action for TBMCS according to this architecture.

Recommendation 4: Lead the development and deployment of an integrated ISR–Command and Control Information Management System to meet the stringent timelines for tailorable and continuously updated information on demand for warfighters worldwide. Provide dynamic ISR response to rapidly and significantly changing situations. Develop the operational architecture, functional requirements, and an implementation roadmap; pursue Air Force–owned elements of the roadmap; and lead a joint DoD-intelligence community initiative for development and deployment.

Recommendation 5: Implement robust AEF communications for rapidly emerging crises, thus enabling immediate combat power for OOTCW crisis response anywhere. Provide Global Grid access; communications to support JBI, and direct links to operational platforms. The multilevel secure communications architecture and requirements for OOTCW are the same as for MTW with the added features of rapid reconfigurability, scalability, and deployability. The AEF hardware, software, and bandwidth environment should be the same as the home station so that we "fight the way we train."

Develop a Spectrum of Tailored Weapons Effects

Recommendation 6: Provide a capability for delivery of directed-energy effects to give the Air Force an OOTCW capability to disable or destroy electronic equipment (for example, computers and ignition systems) and other materiel as well as an antipersonnel capability, without producing blast effects, death, or collateral physical damage. Develop a family of air-deliverable directed-energy effects, including continuous wave and pulsed high-power microwave (HPM) devices and high-energy lasers. Accelerate development of compact high-efficiency aircraft electric prime power sources to enable directed-energy applications.

Recommendation 7: Develop anti-materiel agent technologies, weapons, and delivery methods. This would provide the OOTCW forces with a non-lethal capability to disable or deny to the enemy operation of mechanized vehicles, artillery, and communications equipment, and to disrupt airfield operations and roadways using aggressive biodegradable agents such as supercaustic and conductive foams, embrittlement and depolymerization agents, superlubricants, and petroleum, oil, and lubricant contaminants.

Recommendation 8: Develop methods for destroying or neutralizing chemical and biological agents in bunker storage. The Air Force needs a capability for neutralizing chemical and biological agents in bunker storage situations, with no collateral effect. Critical to this capability is an intelligence capability to provide precise storage location in three dimensions ("in the right room") and the capability to deliver a weapon into the storage location. Conduct a research and development program on an intense heat source.

Recommendation 9: Exploit the potential of UAVs for delivery of lethal and non-lethal effects. Flexible modular UAVs and unmanned combat air vehicles (UCAVs) provide low-cost, long-endurance delivery platforms for a broad spectrum of weapon effects. They provide a low-risk means to fill the gaps in the continuum of required force capability. Develop a family of UAVs and UCAVs with standard payload modules for air delivery of lethal and non-lethal effects, including a family of UCAV weapons for the deep precision attack of mobile targets and HPM, laser, gun, dispenser, and jamming modules. Develop associated external systems for command, control, communications, computers, intelligence, and logistics support.

Recommendation 10: Accelerate development of air-deliverable lethal miniature munitions. The OOTCW missions require tailored lethal effects on fixed and mobile targets with low collateral effects. Accelerate demonstration and engineering and manufacturing development of the Low Cost Autonomous Attack System and miniature munitions.

Maintain Readiness and Presence Within OPTEMPO Constraints

Recommendation 11: Create a Distributed Mission Readiness System (DMRS) from the Distributed Mission Training (DMT) Concept. This would provide a robust and flexible Air Force–wide capability that integrates all force elements to help train and rehearse AEF personnel for full-spectrum global engagement (MTW and OOTCW). Establish overall Air Force leadership for the DMRS; implement the Capstone Requirements Document for DMT and develop it into an Air Force DMRS.

Recommendation 12: Improve airlift responsiveness to OOTCW situations while reducing OPTEMPO impacts. On-time delivery of people and cargo is essential to meeting the mobility requirements of OOTCW without the benefit of mobilization or Civil Reserve Air Fleet activation. Size the airlift force structure on the larger of OOTCW or MTW requirements; reevaluate the active/air reserve component force mix; and increase the active crew ratio. Procure the right mix of C-130J, C-130, and C-17 aircraft and continue or initiate upgrade programs for the C-5 (reliability) and C-130 (avionics). Examine alternative depot maintenance concepts for the KC-135 fleet.

1.4 Organization of the Volume

Volume 2 provides the details of each panel's visits, discussions, deliberations, analysis, and conclusions. The individual chapters contain findings and recommendations which were subsequently distilled for use in the overall Study briefings and summary report (Volume 1).

The Study was framed in the GEO context established by the Air Force Deputy Chief of Staff, Air and Space Operations (AF/XO). GEO is briefly described in Chapter 2, and the reader is referred to the AF/XO compact disk on the subject for more detail. The mapping of the recommendations of the Study into the context of the GEO mission phases is included as Chapter 10.

The Study also referred to the descriptions of small-scale contingency operations (SSCs) described in Tables J-1 through J-3 of the Defense Planning Guidance. These tables provided insight into the types of contingencies to be expected in OOTCW, the nature (duration, timing, forces, etc) of the SSCs, and the historical examples for context.

Finally, scenarios were generated for use by the Study to provide examples of operations to which OOTCW forces could be committed.[1] These are described in Chapters 11 (Somalia 2010) and Chapter 12 (Southwest Asia) and provided us a means to evaluate the applicability of our recommendations.

Appendices provide the Terms of Reference (A), Study Membership (B), and Acronyms and Abbreviations (C).

[1] Vignettes prepared by AB Technologies under contract for AF/XO.

Chapter 2

Global Engagement Operations

(NOTE: During Corona 1999, the term GEO was altered to refer to Global Expeditionary Operations vice Global Engagement Operations.)

2.0 The Relationship of Global Engagement Operations (GEO) to the Summer Study

During the conduct of the study, we found it very useful to think of GEO as a contextual framework for our thought processes about operations other than conventional war. Our Air Force advisors made it clear that the Air Force would use the GEO context in formulating the future force structure and response to the Quadrennial Defense Review (QDR). Thus, we felt it would be appropriate to present our recommendations in a way that clearly shows their relationship to the phases and elements of GEO. This chapter provides a top-level description of GEO. A CD-ROM with complete details is available upon request through the Air Force Scientific Advisory Board Secretariat. In Chapter 10 we present a matrix of our major recommendations, showing how each relates to the phases and elements of GEO.

2.1 Introduction to U.S. Air Force Global Engagement Operations

Under the current national security strategy, the United States exercises leadership in the international community through the policy of engagement. The national military strategy (NMS) supports this policy with the selective use of military force to shape the security environment and to respond to crises. While the Air Force changes organizationally to support the NMS, what is conspicuously absent is the aircrew's view on how the Air Force believes aerospace power helps the NMS to achieve national security objectives. This operational vacuum is the "how we operate" story that complements the Expeditionary Aerospace Force and offers expeditionary options for the Joint Force Commander (JFC) to employ aerospace power in peacetime and in conflict.

In both the 1997 QDR report and NMS, the Secretary of Defense and the Chairman of the Joint Chiefs of Staff introduced an integrated strategic approach embodied by the terms *Shape*, *Respond*, and *Prepare Now*. Successive national security strategies have embraced this approach as a way to address the needs of the post–Cold War environment.

The Shape–Respond–Prepare Now construct builds on the premise that the United States will remain globally engaged to shape the international environment and create conditions favorable to U.S. interests and global security. These shaping efforts endeavor to reduce the frequency of crises. The U.S. military, however, must retain the capability to respond to the full spectrum of crises to protect our national interests. Simultaneously, while managing the operational tempo and personnel tempo caused by both shape and respond operations, the U.S. military must prepare now for an uncertain future. This future could have a sustained tempo much like the 1990s or perhaps a new security environment requiring advanced capabilities and force structure.

Another outgrowth of the first (1997) QDR was the development of the Halt concept as part of the two-major theater war (MTW) strategy. During the QDR deliberations, campaign analysis using the tactical warfare model revealed specific assumptions regarding the use of aerospace forces during an MTW (see Figure 2-1). Essentially the campaign model holds aerospace power in reserve until a decisive ground offensive, instead of sustaining and capitalizing on the capability to conduct counterland or counterinvasion operations.

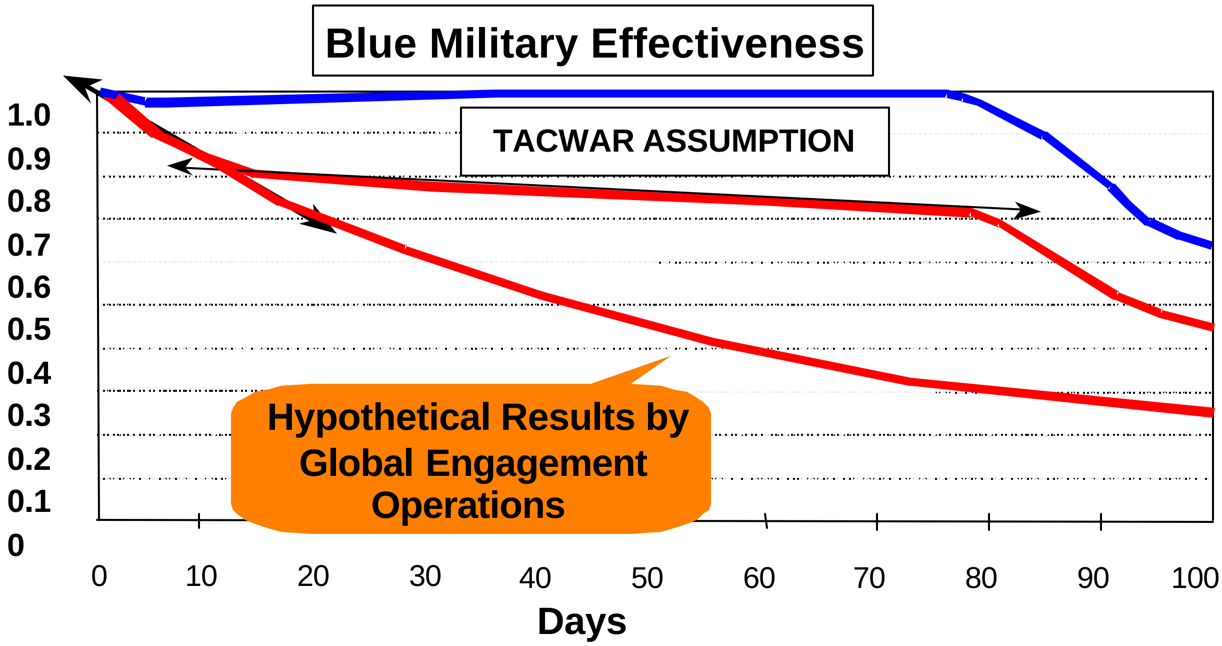

Figure 2-1. *Old campaign analysis assumptions and new hypothetical results from sustained counterland operations using GEO.*

Although a ground offensive is one possible step within the joint campaign, aircrews also wanted to offer the JFC more options (including the "halt the invading forces" phase), each potentially decisive in its strategic effect.

The 1997 QDR recognized that "to rapidly defeat initial enemy advances" was advantageous to the JFC. "Failure to halt an enemy invasion rapidly" would make the joint campaign "much more difficult, lengthy, and costly."[1] Since the QDR report, however, aircrews have recognized several limitations to the Halt concept as first envisioned.

Therefore, with combined and joint operations in mind, GEO accomplishes three goals in regard to the Halt concept. First, GEO incorporates the Halt concept into an operational strategy rather than making it the sole operational mechanism or dominating phase of a joint operation. The Halt capabilities of joint and combined aerospace forces—namely, speed, range, stealth, and precision—had broader implications for joint operations beyond the counterinvasion approach. Rapid, joint expeditionary forces may be able to achieve strategic preemption or "checkmating" actions even before an adversary can act. After halting an adversary, combined or joint forces also have coercive strategy options that may not always include the need for large-scale invasions.

Second, GEO broadens the Halt definition to include military operations across the full spectrum of operations. The Air Force offers a range of halt-like capabilities, from humanitarian missions to the role of strategic forces, which are not narrowly defined to conventional, counterinvasion effects. Finally, GEO bolsters the indivisibility of the Air Force by addressing the wide range of Air Force operational capabilities and effects beyond those specified in the initial Halt concept. Thus, GEO tells a broader "how we operate" story and, in doing so, provides an aerospace-centric operational framework for joint operations.

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[1] "1997 Quadrennial Defense Review," Sec. III, "Defense Strategy," http://www.defenselink.mil/pubs/qdr/sec3.html.

GEO should also tell the Air Force story to three audiences: an internal Air Force audience that needs to hear a unifying message about aerospace power; a joint audience ready to accept a more aerospace-centric view of future joint operations; and finally the American public, which relies on the military to protect its broad interests in the international environment, needs to hear the story of Air Force capabilities.

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Chapter 3
Overarching Recommendations

3.1 Introduction

In the process of interfacing with both operational and technical communities, the Study Team identified some findings that we felt were more pervasive through the operations other than conventional war (OOTCW), as opposed to being identified with a single panel or subject. These findings were of such importance that the group had both inter- and intra-panel discussions as to the extent of the finding, and an appropriate recommendation.

The study found seven "overarching" recommendations involving overall Air Force policy or broad areas of technology or capability. They are expanded in this chapter.

3.2 Global Positioning System (GPS) Accuracy and Survivability

Finding

Most of the weapons that will be used by the Air Force in the 21st century will depend on the GPS for guidance in at least part of their trajectories. The use of GPS guidance has resulted in significant reductions in cost of precision-guided munitions and a substantial improvement in accuracy. GPS guidance is also all-weather, and all-weather terminal seekers are more expensive than GPS systems by a factor of as much as ten. The use of GPS-guided munitions will produce desired effects while saving billions of dollars in weapon costs.

The need for higher precision in weapon delivery has been widely publicized. The development of smaller explosive devices that will produce effects equivalent to, or better than, current guided munitions is underway. The least expensive and most accurate method of guiding the new generation of highly accurate weapons is by use of the GPS. GPS-guided weapons can provide high precision at a cost approximately one-tenth that of a terminal sensor of similar accuracy. Thus, GPS guidance will save the Air Force tens of billions of dollars during the next decade. Cost savings will be more than the cost of the necessary system upgrades.

The key to realizing the full advantages of GPS guidance, though, depends on the achievement of adequate accuracy. The next generation of bombs, which are likely to be in the 500-pound class or smaller, will need to be delivered with errors of 2 meters (m) or less. At present, the GPS is not capable of delivering positioning information at this precision, but achieving such accuracy is possible if straightforward improvements are made in the GPS constellation and ground systems. Positioning accuracy of 1 m, or better, with high jamming resistance can be achieved during the next decade if proposed improvements are made.

It is well known, however, that the GPS signal received at the surface of the earth is very weak. The raw signal, before processing, is well below the thermal noise. Commercial interests in several countries, including Russia, France, and Germany now produce GPS jammers. We are aware of ways to increase the jam resistance of GPS receivers substantially to the point where jammers will become so large that they will become expensive and will be targets for radiation-seeking weapons. Accomplishing this goal requires modernization of both satellites and user equipment. The path to improved jam resistance is well known, but it is not free. The civil GPS signals also require updating.

We recommend that the Air Force collaborate with the Department of Transportation to upgrade both the civil and military capabilities of the GPS. If the Block II R and early Block II F satellites are not modified, it will be at least 2015 before enhanced capabilities can be made available. It is essential to begin the modernization process now.

Recommendation

The GPS is critical to OOTCW. As recommended by the Air Force Scientific Advisory Board (SAB) since 1993, the Air Force should improve the accuracy and survivability. (Assistant Secretary of the Air Force, Acquisition [SAF/AQ])

Proposals have been made to modify the Block II R satellites, which are currently being launched, and the next generation of satellites, the Block II F, to include both military and civil enhancements. On the military side, enhancements include the addition of a new military ranging code and a new data message and increases in the power transmitted by the satellite. Civil enhancements include addition of a civil code on existing frequencies and the generation of an additional civil frequency. The proposed enhancements will result in more protection for this essential weapon system and will make it easier for us to deny the capability to our enemies.

We recommend, therefore, that the Air Force support upgrades to satellites, ground stations, and user equipment to achieve a basic system accuracy of 1 m, or better, without the aid of secondary accuracy enhancements, such as local differential GPS.

3.3 Moving to the Expeditionary Air Force

Finding

The Air Force move toward becoming expeditionary will be a great contributor toward more success in conducting OOTCW. However, the Expeditionary Aerospace Force (EAF) is only starting to crawl, and several areas need more emphasis. These areas include training, communications, deployment, weapons, and basing options. The 1977 study on Aerospace Expeditionary Forces presented many recommendations in these areas that have not yet been implemented, but are needed to successfully and efficiently conduct OOTCW.

The culture of the Air Force must adapt to the rapid small operations characteristic of OOTCW, even while it maintains its traditional capabilities. In many instances OOTCW is not a lesser included case of major theater war (MTW), although it is treated as such in virtually every Air Force function, including planning, training, equipping, and organizing.

The necessary tools, databases, support structure, and organization needed to embrace OOTCW do not exist in places in the Air Force. In particular, the unique planning, logistics, and training aspects unique to OOTCW need to be developed, fielded, and exercised throughout the Air Force.

Recommendation

To successfully transition to an EAF, the Air Force should broaden its focus to encompass training, communications, deployment, weapons, and forward support basing recommendations from the 1997 SAB Aerospace Expeditionary Force Study and this study. (Deputy Chief of Staff, Air and Space Operations [AF/XO])

Specifically, the Air Force should review and act upon the recommendations of the 1997 SAB Aerospace Expeditionary Forces Study including

- Exercising with minimal notice and including logistics aspects and OOTCW unique weapons
- Establishing appropriate worldwide databases for deployment
- Fielding rapid-planning tools
- Pre-negotiating diplomatic clearances and host nation support where possible
- Establishing Regional Contingency Centers

3.4 Non-Lethal Warfare in the Continuum of Effects

Finding

Non-lethal warfare is fast emerging as an important new arrow in the warrior's quiver. DoD has established policy[1] for non-lethal weapons, defense plans have decreed consideration of non-lethal weapons in planning, and the Joint Non-Lethal Weapons Directorate (JNLWD) has been established with the U.S. Marine Corps as the DoD executive agent for the development of equipment and procedures.

The Air Force can and will be a major component of the nation's capability in future OOTCW. Its strategy, vision, and plans must reflect how aerospace power can contribute using non-lethal weapons and means to avoid being less relevant in the 21st century. Toward that end, Air Force leaders must be educated on non-lethal weapons, and aerospace-delivered non-lethal weapons must be included in the development of Air Force capabilities. During the course of the panel's study, no such strategy, vision, or plans were found to exist within the Air Force.

In order to be a significant player in non-lethal warfare, the Air Force needs a strategic vision and strategy for integrating non-lethal means into its arsenal. This includes (1) a doctrinal basis for the Air Force's strategic plans and vision, (2) plans to include the development of non-lethal weapons to be delivered from aerospace platforms, (3) educating Air Force leadership on non-lethal weapons/means, and (4) the Air Force taking its place with the other Services in the development and integration of joint Services (the Air Force should be more involved in the JNLWD).

Recommendation

Develop a comprehensive vision and strategy that takes into full account all potential roles of non-lethal weapons, including "variable effect" and delivery from air and/or space. Integration into the overall response continuum is essential. (AF/XO)

Specifically, the Air Force should

- Develop a comprehensive strategy that takes into full account all potential roles and uses of non-lethal weapons, including delivery of non-lethal effects from air and/or space for strategic and/or tactical purposes
- Develop a vision that realizes the "variable lethality" concept
- "Catch up" and cooperate with the other Services in the ability to effectively employ non-lethal capabilities
- Develop a comprehensive acquisition strategy to develop, test, and procure non-lethal weapons for air operations

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[1] DoD Directive 3000.3, "Policy for Non-Lethal Weapons," 9 July 1996.

3.5 Requirement for Rapid System Acquisition in OOTCW

Finding

OOTCW require development and fielding of urgent, time-sensitive, and new capabilities by use of a very rapid and responsive acquisition process. To give operational commanders a means to meet urgent *wartime* requirements, a process was developed and implemented by DoD. The Rapid Response Process (RRP) had its origins in Desert Shield and Desert Storm[2] and has continued in use during the crises in Bosnia and Kosovo. It is implemented in Air Force Instruction 63-114, dated 5 May 1994. Compliance is mandatory. The RRP recognizes the ability of the commanders in chief (CINCs), major commands (MAJCOMs), and headquarters (HQ) to identify the critical situations which require urgent, time-sensitive solutions for OOTCW as well as conventional war.

The RRP is described as follows[3]:

> "[It is used] to accelerate the fielding of critical systems to meet theater-specific wartime needs. The RRP does not replace normal acquisition procedures; but rather speeds up the process of fielding systems to satisfy wartime needs.
>
> The RRP starts when the HQ Air Force, MAJCOM, and warfighting CINCs issue an urgent, time-sensitive Combat Mission Needs Statement (C-MNS). The C-MNS, processed in accordance with AFI 10-601, is validated by the operator MAJCOM and sent to the Deputy Chief of Staff for Air and Space Operations, Directorate of Operational Requirements (HQ USAF/XOR) for action. Within 48 hours, HQ USAF/XOR presents the C-MNS to the Air Force Chief of Staff for approval.
>
> The criteria for implementation of the RRP in lieu of the normal acquisition procedures for a system is:
>
> - Quickly fielded (normally within 60 days from authorization)
> - Supportable in-place
> - Affordable
> - Acceptable risk
>
> The RRP should take no longer than 16 days from the receipt of the C-MNS to the issuing of the Program Management Directive.
>
> SAF/AQ and Deputy Chief of Staff for Air and Space Operations (HQ USAF/XO) are jointly responsible for implementing the RRP."

Use of the RRP in crises such as Bosnia and Kosovo (where over 20 C-MNS were acted on) shows its utility for OOTCW.

Recommendation

Ensure that the RRP remains viable to define, develop, and deploy urgent, time-sensitive systems identified by the CINC as critical to combat operations, including OOTCW. (SAF/AQ and AF/XO)

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[2] "The USAF Desert Shield/Storm Rapid Response Process," Briefing to the Middle East Aerospace and Defense Conference, Maj Gen Bob Eaglet, February 27, 1991.

[3] Air Force Instruction 63-114, "The Rapid Response Process," May 5, 1994.

The RRP provides results across a wide variety of mission areas and is generally regarded as a success; however, some have argued that its limitation to *critical and urgent* warfighting needs allows the other acquisition programs to remain unaffected and thus too far removed from the CINC's influences.[4]

This Summer Study reiterates the need, expressed in earlier SAB reports, to improve the cycle times for system development and to continue other essential acquisition process reforms for the *normal* acquisition process and procedures. However, in our judgement there are no unique requirements for additional acquisition process changes that are driven solely by OOTCW. We fully endorse continued use of the RRP in meeting critical, urgent, time-sensitive, and theater-specific OOTCW requirements.

3.6 Coupling of Defensive and Offensive Information Warfare

Finding

Defensive and Offensive Information Warfare have different objectives and are carried out by different organizations. The Force Management Panel examined Defensive Information Warfare and Information Assurance, while the Non-Lethal Effects Panel examined Offensive Information Warfare. At the execution level, the distinction and separation of the two areas are proper. However, at the science and technology level, at the development of strategies, concepts, and techniques, the two areas should be closely linked and, indeed, each community should provide an intellectual and operational challenge to the other. The argument in favor of the close linking of the two is perceived to be much stronger than the argument in favor of separation for security reasons.

The rapidly changing information collection, storage, and dissemination environment, where the means (hardware and software) for access are becoming widely available and inexpensive, indicates that a substantial advantage may be obtained by the timely exploitation of a new capability or vulnerability. That advantage, however, will last only a short period of time: until it becomes widely known and countermeasures are taken. The exploitation of a temporary advantage rewards those who can identify and act in a timely manner—whether to exploit the adversary's temporary vulnerability or to protect our information from that vulnerability, or both.

Consequently, it stands to reason to encourage cross fertilization of ideas, strategies, and techniques from both offensive and defensive points of view. At the same time that a perceived vulnerability appears, we should be developing simultaneous techniques for exploiting it and techniques for protecting ourselves, were the adversary to recognize the same vulnerability. Similarly, the identification of a temporarily effective technique used by an adversary should lead to the rapidanalysis and exploitation of the technique by our forces in appropriate situations.

Recommendation

Ensure that the development of strategies, concepts, techniques for offensive and defensive information warfare are closely coupled for maximum effectiveness. (AF/XO and SAF/AQ)

The key notion here is that a sequence of narrow windows of opportunity will be appearing as the information systems become more complex and more integrated. The timely recognition of these windows, and their concurrent exploitation in Offensive information operations (IO) and protection of our systems through Defensive IO, mandate that the Defensive and Offensive IO communities be closely coupled, sharing concept definition, science and technology investments, and the development of strategies and techniques.

[4] Lt Col J. E. Smith, "Operational Acquisition—An Oxymoron?," Program Management magazine, March-April 1999, pages 24-29.

3.7 Defensive Information Warfare

Finding

The rapid development and proliferation of information technology and the availability of the means and the knowledge to attack military information systems and civilian ones on which military operations depend, has made information assurance one of the pillars of information superiority. Effective information assurance requires the reduction—to the extent that is technologically and operationally feasible—of the vulnerability of our networks and the information they carry, and the ability to detect, assess, and take effective action against attacks.

Defensive Information Warfare was an area that was addressed by the Force Management Panel to the extent possible within the classification parameters of the study. It was observed that the Air Force has made substantial progress in addressing selected aspects of the problem in parallel with related DoD efforts. Firewalls, network monitoring, and website reviews are in place. The requirements of OOTCW require enhanced vigilance because such operations generally require collaboration and sharing of information with a wide variety of civilian and nongovernmental organizations.

One of the complexities of the problem is that it is very dynamic; once a defense to a problem has been found and implemented, the adversary will seek to exploit a new vulnerability. Furthermore, layering all available safeguards may degrade performance. Therefore, protection mechanisms have to be employed selectively so as to minimize vulnerability while not causing a decrease in capability.

Recommendation

The critical requirement for information superiority suggests increased emphasis on defensive information warfare, including assessment of detected threats and development of responses.

One can safely assume that our information systems cannot be made perfectly invulnerable so as to discourage attacks from adversaries, that is, protection cannot be complete and absolute. We need to focus on how to detect, assess, and respond to threats, whether they consist of isolated intermittent attacks over a long period of time or massive attacks over a short period. The panel observed that major progress has been achieved in the detection part. But that is not sufficient. Tools and techniques need to be developed that will allow a timely assessment of the effect of the attack, both in terms of identifying specific system vulnerabilities but also in terms of the information and systems that may have been compromised. Furthermore, there is need for a whole spectrum of responses as well as a set of guidelines for matching the type of threat with the appropriate response so as not to compromise our information assets.

While significant efforts along these lines have been undertaken within the Air Force Research Laboratory in concert with other relevant DoD entities (for example, the Defense Advanced Research Projects Agency and the Defense Information Systems Agency), the panel observed that while protection and detection efforts are moving forward, attack assessment and especially response selection (for example, whether to contain, deny, or destroy the attacker) need an infusion of ideas and concepts. Particular attention should be paid to the attack from within—to assess its (potential) damage and develop strategies for its containment.

3.8 Technology Base Flexibility for OOTCW Needs

Finding

There are a number of factors that currently hinder the Air Force's ability to engage in the necessary "technology push" for revolutionary OOTCW-related capabilities. These include the current defense

planning process and the focus in the research, development, and acquisition process on users ("customers") who are quite unlikely to generate requirements for new and revolutionary capabilities ("technology pull") which take full advantage of the possibilities offered by enabling technologies.

Because the current defense planning paradigm tends to focus on MTWs and tends to treat OOTCW as "lesser-included cases", it is incumbent on the Air Force to ensure that the unique or more stressing requirements of OOTCW are considered carefully in the requirements, research, development, and acquisition process. Because of the high peacetime operational tempo and budget pressures, there is tension between current operations and extant tasking. Investing in, or even considering, requirements for new and revolutionary OOTCW (or even MTW) capabilities that might dramatically improve performance or reduce costs tends to be neglected. This will require constant attention.

Finally, the need for improving the technology push for OOTCW-relevant capabilities includes the need to improve the Air Force's process for developing revolutionary technology breakthroughs that can provide the precision, survivability, and other performance characteristics of aerospace power that are needed in an OOTCW setting, and can provide forces that are more suitable to the tight constraints (for example, on friendly casualties and collateral damage) that are frequently imposed on aerospace operations.

We recognize that fiscal constraints and acquisition policy drive the acquisition community to expend most of their effort on user requirements, rather than pursuing revolutionary technology breakthroughs. Nevertheless, science and technology (S&T) resource allocations must assure a balance between technology pull and technology push. It should be remembered that without an unyielding technology push, the Air Force would not have the E-3 Airborne Warning and Control System, the E-6C Joint Surveillance, Target, and Attack Radar System, and the F-117 Stealth Fighter.

Recommendation

The Air Force should ensure that discretionary funds are available to laboratory managers to focus on promising technologies and revolutionary capabilities. Encourage industry independent research and development managers to do the same.

The Air Force should continue its efforts to anticipate the emerging requirements of the OOTCW mission area, as well as enabling technology push solutions. This will require changing the incentives and resources that are available to technology developers to better ensure that the technology base will continue to provide revolutionary breakthroughs. A system of incentives and exchanges is required to reduce the constraints on researchers who are doing long-term (revolutionary) work and to make a more systematic effort to educate consumers (the warfighters) about the possible operational concepts that might be enabled by technology breakthroughs.

More specifically, SAF/AQ must ensure the *balance* of resource allocations such that the S&T community

1. Is responsive to the long-term operational capability requirements formally established by the warfighter
2. Is responsive to short-fuse urgent breakthrough needs identified by operational and technical activities
3. Can conduct developments under the discretion of the Lab Directors to take into account both innovative technical concepts and anticipated future warfighter needs

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Chapter 4
Intelligence and Vigilance

4.0 Introduction

This report elaborates on the work of the Intelligence and Vigilance (I&V) Panel. The tasking to this panel can be found at the end of this chapter in Appendix 4A.

4.1 Environment

The task of defining technologies to support I&V for operations other than conventional war (OOTCW) presented several challenges. The first challenge involved constraining the definitions of the terms "intelligence" and "vigilance." The panel chose a broad and inclusive definition to include technologies and systems that provide situational awareness and operational and observational readiness. More specifically, the panel focused on

- The collection and development of data from or about targets, the distillation of these data into knowledge, and the dissemination of derived information to those who can use it to decide or act
- Understanding the actions and inferring the intents of potential adversaries
- The ability to project real or perceived U.S. presence, knowledge, and power
- The ability to provide rapid response capability to a wide variety of stimuli over large geographic regions
- The ability to conduct effective demonstrations of knowledge, force, and control for a sustained period of time

4.1.1 Approach

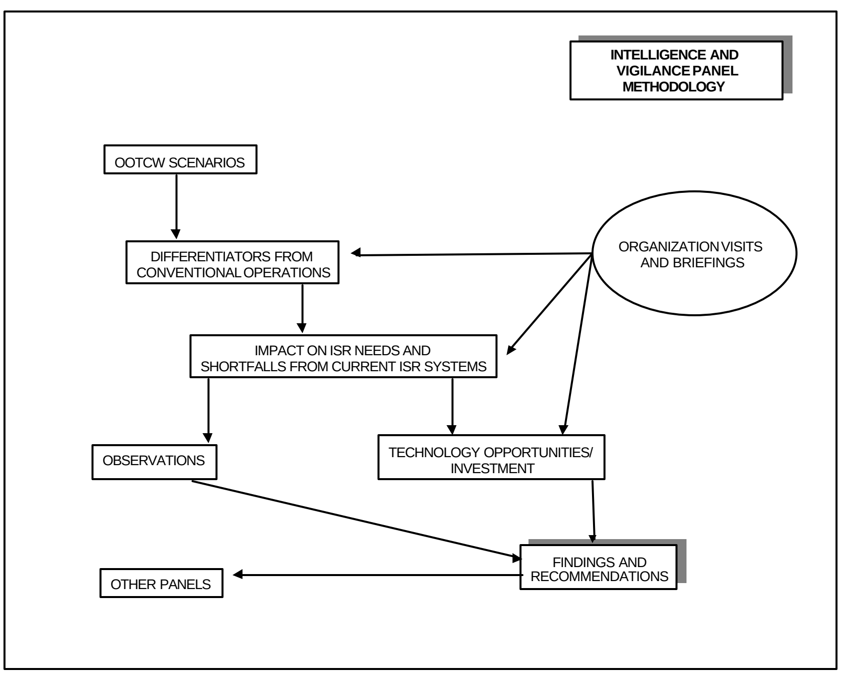

Figure 4-1. *Intelligence and Vigilance Panel Methodology*

Figure 4-1 shows the methodology used by the group to derive technology investment opportunities from OOTCW missions and their intelligence, surveillance, and reconnaissance (ISR) needs. The panel first collected a list of scenarios and vignettes that span a variety of OOTCW situations. The group of vignettes was then examined and inferences drawn with respect to general factors that differentiate these situations from conventional war. The impact of these differentiating factors on ISR needs—with particular emphasis on the classic intelligence tasking, collection, production, evaluation, and dissemination (TCPED) cycle—was then addressed in order to identify ISR shortfalls. Finally, the group examined the merits of various approaches to address these shortfalls.

Throughout this process, the panel was exposed to a broad range of intelligence community, technology, and operational activities through on-site visits, demonstrations, and briefings. This exposure was invaluable in supporting the panel's efforts.

The panel chose to generalize the scenarios as they flowed down requirements to technologies in order to keep from getting entangled in the details or discriminating factors between individual OOTCW scenarios. However, to ensure that this generalization did not dilute the results of specific recommendations, several vignettes were passed through the process to verify that the process outputs remained relevant.

4.1.2 Differentiators Between Conventional War and OOTCW

A challenge arose in differentiating between "conventional" and "other than conventional" warfare in terms of ISR needs, current system capabilities, and shortfalls. In consideration of the Somalia 2010 vignette and the potential situations that might derive from it, several conventional war and OOTCW differentiators became apparent and are displayed in Table 4-1.

Table 4-1. *Differentiating Factors Between Conventional War and OOTCW in Terms of ISR Needs*

Factor	***Conventional War***	***OOTCW***
Acceptability of Collateral Damage	Low	Extremely low
Target Nature	Target structure understood; military and political forces	Target structure needs study; individuals/small groups
Nature of Adversary Equipment	Mostly military, some commercial	More commercial
Urban/Rural Mix	Even	More urban
Weapons of Mass Destruction Threshold for Use	Very high	Medium
National Boundaries	Understood	Perhaps transnational
Clarity of Opponent Intent	Identified and understood	Unclear and not well understood
Own Force Composition/Command and Control (C^2)	U.S. identity; C^2 well defined	Coalition/North Atlantic Treaty Organization/United Nations; multiple or consensus C^2
Indications and Warning	Ongoing ISR	Global potential inhibits ISR; ambiguous indicators
Operational Planning	Advanced preparation	In reaction and "on-the-fly"
Rules of Engagement (Friendly Fatalities)	Some tolerance	Very low tolerance
Duration/Intensity of Hostilities	Time limited/high intensity	Variable (perhaps very long); low intensity
End State	Usually clear	Usually unclear

The Assured Support to Operational Commanders (ASOC) document describes the military operational intelligence requirements during conventional war and OOTCW. While the Air Force's Global Engagement Operations (GEO) strategy was developed after the ASOC was published, the panel felt that the strategy would likely not drastically change the essential elements of information codified in the document.

Based on the ASOC, the primary differences between conventional war and OOTCW in terms of ISR needs appear to be

- Timeliness: The amount of time from a triggering event to the point when dominant battlespace awareness is achieved is very short. Historically, conventional war operations are preceded by months of force buildup and ISR preparation of the battlespace. OOTCW (as defined for this study) are often required within days or weeks after such an event, driving ISR timelines to as little as hours or minutes.
- Area of coverage:
  - An OOTCW could be required anywhere in the world, and several of them may occur simultaneously.
  - The area of specific interest in a given operation is smaller—on the order of thousands of square nautical miles instead of hundreds of thousands.
- Level of detail: Monitoring the actions and understanding the intentions of very small units (or even individual people) can be critical to mission success.
- Political or legal preparation: Sudden and surprising events place forces in jeopardy without time for congressional preparation.

4.2 Impact and Shortfalls

With consideration of the above differentiating factors and in light of current and planned ISR capabilities, the panel made the following observations:

- The traditional ISR TCPED cycles are clearly tuned to conventional warfare. They are designed for the careful selection of a limited number of targets, distributing the target list to the battlefield commander, and providing battle damage assessment (BDA) for these targets day in and day out over a protracted shooting war. The panel found that, in many OOTCW situations, the environment might be significantly shaped, or the desired results achieved, by U.S. application of "asymmetric" demonstrations of very-short-time-cycle sensor-to-shooter capability. An example might be the destruction of a building containing terrorists 10 or 15 minutes after a human intelligence (HUMINT), signals intelligence (SIGINT), or imagery intelligence (IMINT) tipoff.
- Because nearly half of the world's population lives in urban areas, targeting (and attack) methodologies that minimize collateral damage while providing militarily useful effects will be needed. The ability to target and deliver low-cost small weapons and sensors with extreme precision is needed.
- As the threat of the use of weapons of mass destruction (WMD) and of other terrorist actions is high, there is a need for near–real-time processing of intelligence data. Such processing must be done in theater (on the Rivet Joint, for example), or datalinks must be developed to centralized facilities that can produce near–real time results.
- The fact that terrorist groups (perhaps with WMD) might operate in the United States complicates their tracking by intelligence agencies because of legal restrictions. Nevertheless, the Air Force,

because of its mobility and equipment, might be best suited to be the first responder to a threatened or actual terrorist incident in the United States.

- The unpredictable timing and locations of OOTCW can require military personnel to enter obscure parts of the world with very little knowledge of the areas that they are entering. There is no single organization charged with collecting data to create a "Michelin Guide" for Intelligence Preparation of the Battlespace for every country. As many early-entry situations in OOTCW include the threat of local hostilities, early entrants require a broad variety of practical, logistical, cultural, and tactical information. The threat to military forces from small local groups requires U.S. military forces to understand the local infrastructure (for example, the telephone system, broadcast information services, armories, gun laws, and police organization) because this infrastructure might be used against them.
- The indefinite start and end times and the potentially very long duration (perhaps years) of some OOTCW (for example, no-fly-zone support) requires an operational tempo (OPTEMPO) that is inconsistent with the U.S. and allied portfolio of airborne ISR systems—for example, the Airborne Warning and Control System (AWACS); the Joint Surveillance, Target, and Attack Radar System (JointSTARS); and Rivet Joint (RJ). It would not be affordable to replicate and staff these systems in the numbers required to support long-term, low-intensity missions. Alternative methods for long-term ISR for low-intensity situations are required.
- The Air Force is better suited than the other Services to insert small-sensing systems far across enemy lines for situational awareness. The deep presence and high ground offered by Air Force platforms offer the potential for the insertion of a variety of unattended or robotic sensors that can provide key situational awareness information for a lower cost, and with much less risk to personnel, than with alternate methods such as a staffed Special Forces operations.
- Differences in geodetic coordinate systems used by various Services and agencies complicate the process of providing timely and accurate targeting to early joint-force entrants.
- The environments within which the U.S. military will most often conduct OOTCW are areas of low technology. For example, in Africa, high-frequency and very high-frequency radios are the norm for communications, both long haul and local. Situational intelligence gathering in both humanitarian and peacekeeping, peace enforcement, and peace making will be limited by local technology levels, and availability of HUMINT. In an age when Morse code is often not even taught to U.S. Air Force communication technicians, and computer controlled satellite systems are the norm, operations in the underdeveloped and problematic parts of the world have a unique "low-tech" factor that must be acknowledged and understood.

4.3 Findings and Recommendations

4.3.1 Finding: OOTCW Have Unique Information Needs During the Early Phases of GEO.

The Expeditionary Aerospace Force (EAF) provides an essential element in this nation's ability to rapidly respond to global crises and OOTCW. Successful accomplishment of the early phases of the GEO strategy depends to a large measure on the completeness and currency of both global situation awareness and the ability to tailor that information to specific areas and missions.

There are several shortfalls in the current capability to establish and maintain global situational awareness. Current country handbooks are either obsolete or inadequate for OOTCW mission planning. Little effort is apparent in establishing the level of information readiness necessary to effectively support a wide range of potential OOTCW missions and areas. The intelligence community processes for battlespace preparation today emphasize high-priority areas and elements of information biased toward supporting conventional war and large-scale combat operations. The recent experience and anticipated

future employment of the military force argue strongly for an expansion of U.S. intelligence information readiness posture to include the full spectrum of GEO and specifically, the information needs for OOTCW.

There is a strong likelihood of joint or coalition involvement in most future operations. This fact will introduce dimensions of interoperability and releasability that must receive careful consideration in the development of an intelligence information support architecture.

Recommendation: Develop a Global Intelligence Guide Usable for Specific OOTCW Areas and Missions.

The Global Intelligence Guide is a collection of geographic, historical, political, economic, and military descriptions of all countries of the world as they are at any given time. It is an electronic country guide prepared, stored, and available at the highest security level, but also published and distributed to field units, training elements, and coalition partners at an appropriate classification level.

The Global Intelligence Guide will provide the required level of intelligence information readiness to the EAF throughout the Shape and Deter phases of GEO. It is an important initial element in the intelligence preparation of the battlefield as the *a priori* database for the Joint Battlespace InfoSphere (JBI) and also as an essential element in the training process of the Aerospace Expeditionary Forces (AEFs).

Table 4-2. *Sample Contents of the Global Intelligence Guide*

General Information	*Geographic Information*	*Military Information*
• Description of the country • History • Language, literature, art • Customs, religion, food • In-country behavior • Work patterns • Political, administrative organization • International relations and treaties • Highlights of the economy • Industry, employment • Current leadership • Political situation • Economic situation	• Geographical maps with terrain features in WGS-84 format • Cities, towns, villages, and all manmade structures on the geographical maps • Street maps of cities with current names • Roads, bridges, airports, sea and river ports, railroads, power plants, power lines, gas lines, dams, water supplies, communications systems, and all other infrastructure located on and referenced to the geographical maps • Important historical, cultural, medical, and diplomatic facilities • Scientific and educational centers • Refineries, industrial plants, and other significant economic facilities • Images of all significant features	• Military command structure • Location of military headquarters and command posts • C^2 infrastructure • Location of all military facilities • Location of military logistics depots; including personnel strengths, amount, and type of stocks and equipment • Location of suspect clandestine sites • Location and disposition of opposition forces, if any • Status of military agreements and alliances • Other militarily significant information of a long-duration nature

The preparation and maintenance of the country-specific Global Intelligence Guide poses daunting financial and manpower challenges. However, new data-retrieval techniques and proposed mapping systems are making their appearance in the commercial world and promise to greatly reduce the cost of implementation.

The Air Force Research Laboratory (AFRL) and the Electronic Systems Center, in cooperation with the intelligence community, should be tasked to review currently available commercial systems and initiate programs to develop the following:

- Automated techniques for critical data development and mining
- Automated library search engines for archival data
- An accelerated process for the generation of high-accuracy geodetic maps of the world
- Opportunistic techniques for extracting incidental intelligence data and overhead coverage of current low-priority targets
- Architecture and software for simultaneous registration of geospatial and contextual information

The Air Intelligence Agency (AIA), as the implementing Air Force organization, should work within the intelligence community to *apply* the recommended technology initiatives.

The following implementation recommendations address efforts integral to development of the Global Intelligence Guide:

- The Air Force Deputy Chief of Staff For Air and Space Operations should document EAF information needs and develop a framework for a Global Intelligence Guide that provides the information needs for OOTCW, tailorable to a specific area of operations. Information needs specific to AEF employment should be developed for the range of anticipated missions. Integral to this step is the identification of available source information to satisfy those needs as well as the anticipated shortfalls.
- The Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center (AC2ISRC), with AIA, should represent the Air Force in a joint effort, under the Defense Intelligence Agency, to establish, define, and implement a Global Intelligence Guide for accelerated information readiness. It must be recognized that an intelligence guide of this scope will have applicability to other Services, and in some cases, to coalition partners. The Air Force should strongly support initiation of a joint effort to develop the Global Intelligence Guide.
- The Global Intelligence Guide should be used as the *a priori* database in preparing the JBI. This additional recommendation recognizes the significance of the JBI and the contribution that can be made by the Global Intelligence Guide. As the foundation of a tailored intelligence information database, the guide is envisioned as the departure point for developing dynamic ISR support during the subsequent phases of GEO.

4.3.2 Finding: OOTCW Scenarios Overstress ISR Platforms (for example, Space, U-2, E-3, E-8, RC-135) and Personnel Already Heavily Committed, Even in Peacetime.

There is such a near unanimity among the various producers and users of ISR data that the demand for quality ISR products dramatically exceeds the Air Force's ability to comfortably supply them. The primary airborne ISR collectors (AWACS, JointSTARS, RJ, U-2) are operating at OPTEMPO and personnel tempo, which puts stress on both equipment and personnel. Demands for ISR products exceed supply in OOTCW as well as in inconventional war (for example, Kosovo). Although the recommendations made in this report focus on OOTCW shortfalls, if these recommendations are acted upon, the resulting new capabilities will help to augment conventional wartime capabilities as well.

OOTCW add particularly stressing requirements to ISR systems. First, in the buildup phase (that is, the Shape phase) prior to hostilities, indications and warning (I&W) intelligence information is required to track the activities of potential belligerents and gain early insight into the possibility of imminent military action. ISR products (and hence ISR assets) are required months and even years before combat or the

GEO *Respond* phase of a crisis. For example, the North Atlantic Treaty Organization AWACS had been on patrol for 2 years before the Kosovo crisis came to a head. Twenty-four–hour surveillance of these regions with critically valuable assets such as AWACS and JointSTARS is simply not feasible because of the limited number of aircraft and crews available. The Reshape phase also stresses ISR systems. Enforcement of a resolution to end hostilities might require years of surveillance of the once-belligerent parties. No-fly zones, which were unheard of 10 years ago, are now part of the popular lexicon. Enforcement of no-fly zones (for example, southern Iraq and northern Iraq) is placing extraordinary demands on AWACS planes and personnel.

Before recommendations can be made to ease the problems described above, it is informative to look at the separate missions performed by the various ISR platforms and the needs for those missions during various operational phases described in the GEO construct. There are two main classes of ISR systems:

- Those that do sensing alone. Examples include U-2, RJ (that is, RC-135), and most unmanned aerial vehicles (UAVs).
- Those that both sense and have onboard battle management command and control (BMC^2) functionality. AWACS and JointSTARS are the primary examples in this category.

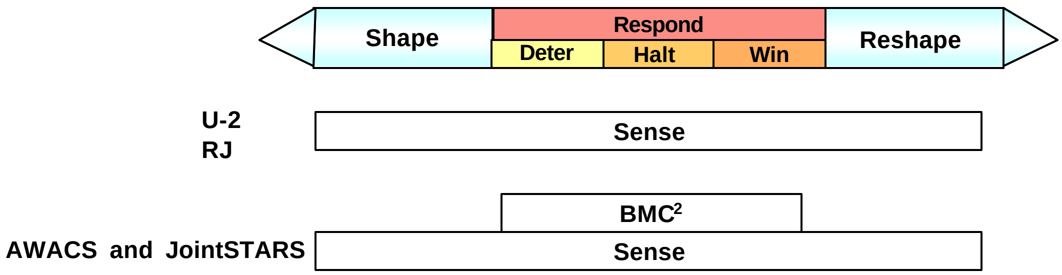

Figure 4-2. *Use of Current ISR Platforms Across the GEO Spectrum*

Figure 4-2 depicts how these two classes of ISR platforms are used during a conflict. During the Shape and Reshape phases, ISR assets are overtasked due to the need for vigilant I&W, which is a sensing mission (versus a BMC^2 mission). During the hostility phases of the action, both sensing and BMC^2 capabilities are needed simultaneously in theater.

There are two possible strategies for filling the required ISR shortfalls for both conventional war and OOTCW:

- Buy more platforms of the existing types (for example, AWACS and JointSTARS)
- Take advantage of the fact that the sensing mission is very well suited to the use of unmanned platforms and augment the existing system with UAVs

Several previous studies, including the 1997–1998 Airborne Radar Study (ARS) by the Office of the Secretary of Defense; the Command, Control, Communications, Computers, and ISR Mission Assessment Study by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence; and six recent Air Force Scientific Advisory Board (SAB) studies examined the acquisition, operating, and life-cycle costs of manned ISR platforms and UAVs. Each of these studies showed convincingly that UAVs are significantly less expensive than their piloted counterparts. *This result should not be interpreted as a statement that UAVs are inherently superior to their piloted systems*. Because of the BMC^2 capabilities of the manned platforms, any direct comparison of the manned platforms to UAVs is an “apples to oranges” comparison.

The ARS suggested a model for piloted and unpiloted operations that allows the UAVs to augment the piloted systems in such a way as to relieve the OPTEMPO problems for the manned platforms in both OOTCW and conventional war. This model is shown in the familiar GEO model in Figure 4-3 and is depicted in Figures 4-4 and 4-5 in cartoon form.

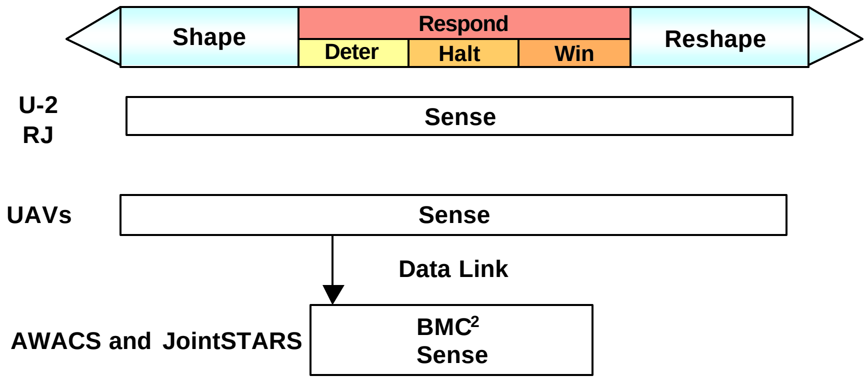

Figure 4-3. *Operations with UAV Augmentation Across the GEO Spectrum*

During the Shape and Reshape phases, UAVs provide I&W for long periods. When hostilities begin, the manned platforms are activated to provide both sensing and BMC^2 functions. With the implementation of suitable communication links between the UAV platforms and the manned platforms, a "hen and chicks" architecture can be implemented, as shown in Figure 4-5.

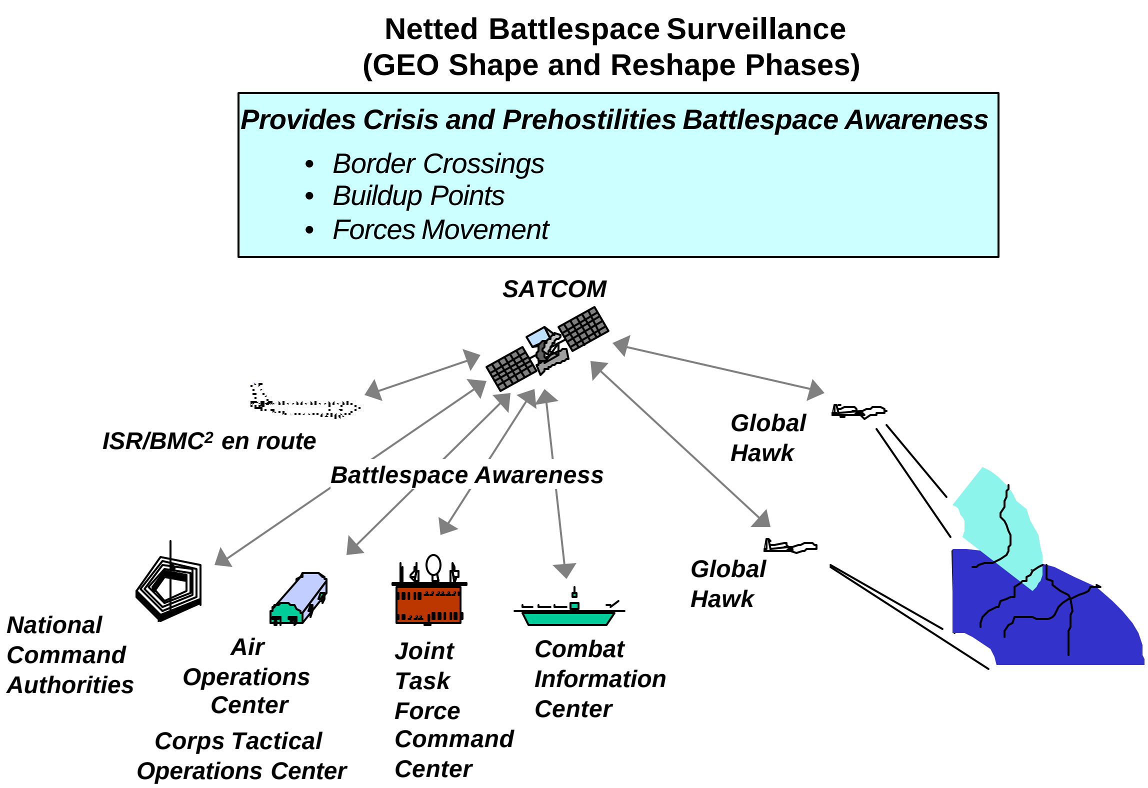

Figure 4-4. *Netted ISR during Shape/Reshape Phases*

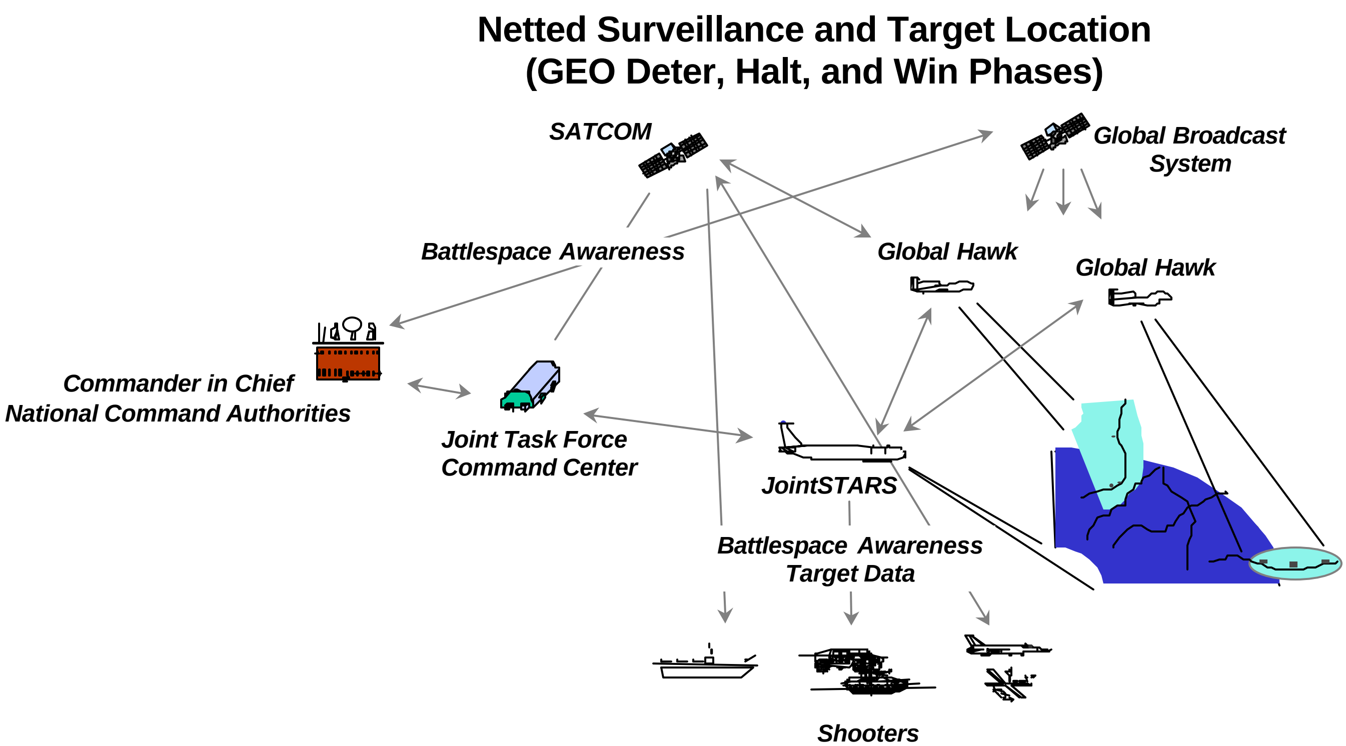

Figure 4-5. *Netted ISR during Deter/Halt/Win Phases*

With this architecture, the UAVs feed additional sensing inputs into the command and control (C^2) functionality of the piloted aircraft. During hostilities, the UAVs can sense more deeply into enemy territory since they can be flown very aggressively.

The net effect of this proposed architecture is a reduction in the required OPTEMPO for the manned platforms during the Shape and Reshape phases (with no loss in I&W) and significantly augmented sensor information during the hostility phase.

Recommendation: The Air Force should begin a program to augment Air Force and national ISR Capabilities with UAV-based systems.

The I&V Panel recommends that the Air Force transition the existing Global Hawk platform into production as soon as possible for its intended air-to-ground electro-optical/infrared (EO/IR) and synthetic-aperature radar (SAR) imaging purposes.

Several ISR capabilities could be added to the Global Hawk platform. Because the AWACS platforms and their crews are extremely overtasked, *the first new ISR capability after the current Global Hawk is fielded should be an air surveillance mode-using radar and an Identification–Friend or Foe system.*

The panel believes that radar technology is sufficiently mature to allow for the immediate development of the required radar by industry. This belief is substantiated by the results of the ARS, which surveyed radar technology programs and explored the capabilities of the existing Global Hawk airframe and possible improvements to the vehicle and its sensor suite.

Although the panel has stressed airborne early warning (AEW) and Global Hawk, other combinations of mission and UAV are also attractive. The SIGINT mission is an obvious alternate mission. The close access to the target offered by UAVs makes them capable platforms for the interception of wireless and

personal communications. The low-power levels and frequency reuse plans for these communications systems makes close access collection the logical, if not the only feasible alternative. *The panel recommends that the Air Force begin or continue research and development (R&D) in the signal intercept area and begin planning for a SIGINT payload for Global Hawk*.

To initiate the definition of the new UAV-based sensors, the Air Force (Assistant Secretary of the Air Force, Acquisition [SAF/AQ]) should sponsor a study to perform the following tasks:

- Update the results of the 1997–1998 Airborne Radar Study and other related studies and investigate implementation options for Global Hawk AEW.
- Study alternate ISR missions for Global Hawk. SIGINT is the most obvious potential mission. Past Global Hawk SIGINT studies (for example, the Defense Airborne Reconnaissance Office's Joint Aerospace SIGINT Architecture) should be reviewed. With respect to OOTCW, particular emphasis should be placed upon personal wireless communications.
- Consider the relative merits—cost, technology, concept of operations, etc.—of a multi-intelligence ISR sensor payload versus palletized payloads that perform a single function.
- Propose an Air Force program to develop the sensor package(s) recommended. Such a program should leverage the approximately $8.5 million that the Defense Advanced Research Projects Agency (DARPA) has programmed for the development of advanced radar technology for Global Hawk.

Relevance of Space and Discoverer II for ISR

It is understandable that many are encouraged by the promise offered by space-based systems such as the joint Air Force–National Reconnaissance Office (NRO)–DARPA Discoverer II. The panel believes that the technology envisioned by the Discover II program is worth pursuing. However, the implementation timeline and system cost for Discoverer II put it in a significantly different class from the UAV systems recommended above.

While Discoverer II is boldly taking on the SAR IMINT and ground moving-target indication (GMTI) missions, the implementation of a full constellation, including the required TCPED systems, will be a long and expensive undertaking. The panel believes that the ISR missions of EO IMINT, SAR IMINT, GMTI, SIGINT, and AEW are progressively more difficult when implemented from space. (The complications with future space-based SIGINT systems are well understood by the intelligence community and are best handled at a classified level.)

The AEW mission is generally accepted to be several orders of magnitude more difficult than the SAR or GMTI missions when attempted from space. The difficulties are due to the following factors:

- The significantly higher transmitter power and antenna size required for AEW in comparison to GMTI due to smaller target size and shorter dwell times.
- The dramatically higher requirement for antenna mechanical stabilization to cancel ground clutter.
- The larger constellation size required to track tactically maneuvering aircraft. Target-tracking algorithms cannot maintain ambiguity-free tracks with the several-minute between-pass dropouts characteristic of Discoverer II.
- Tracking systems for airborne target traffic might be significantly different from those for GMTI since air traffic is not constrained to lie on existing highways (an inherent assumption in the baseline Discoverer II ground-target tracking algorithms).

The panel also believes that space-based radar systems (SAR, GMTI, and AEW) will be inherently more vulnerable to jamming and denial and deception. The deterministic orbit times and very wide mainbeam footprints make satellites attractive targets for intentional jamming. Despite dramatic advances in electronic counter-countermeasures (for example, adaptive nulling), no techniques exist to counter powerful jammers in the radar mainbeam. The relatively close range from a UAV to the target area and the unpredictable sensor trajectory make jamming of airborne ISR systems significantly more difficult because the mainbeam footprint area on the ground is generally significantly smaller.

The ARS, as well as the 1998 SAB Space Study, briefly examined the relationship between space-based and airborne radar systems and agreed that space-based approaches were of a “higher risk” and would have a “later epoch than airborne options.” Nevertheless, like the ARS Panel, the I&V Panel agrees that the potential for deep access and broad coverage makes space-based radars very attractive, and we endorse continued R&D and technology demonstrations.

4.3.3 Finding: The Observables Required for Evolving Targets and Environments Demand Development of New Methods and Exploitation of New Phenomena.

The threats that may be present in future conflicts, particularly OOTCW, will present a broad spectrum of observables requiring new ISR sources and methods. These targets and/or environments include

- Chemical and biological agents
- Underground facilities
- No-fly zones
- Cantonment areas
- Urban targets
- Networks and cyberspace
- Digital and wireless communications

Several emerging technologies that can dramatically improve intelligence collection capability against these targets are being developed. Some examples of these technologies are

- Miniature chemical and biological detectors based upon micro electro-mechanical systems (MEMS), including electro-optical, conductive polymers, and live-cell interactions
- Miniature and sensitive conventional chemical and biological detection techniques such as mass spectrometry and mobility spectrometry
- Millimeter-wave radio frequency systems for high-resolution imagery from small systems
- Ultra-miniature MEMS acoustic and seismic measurement devices
- Ultra miniature and ultra-low-power electronics
- Low-power communications, including commercial satellite systems such as Iridium and Orbcomm
- Uncooled infrared detectors

The panel found that new classes of delivery vehicles are required to deploy these sensors from existing Air Force assets. Of the military Services, the Air Force is the best positioned to develop deployment of such sensors because Air Force assets can operate broadly and deeply into denied territory on a short timeline. The panel found that the Air Force is rich in component technology that allows for the development of a broad range of new delivery options for small sensors. Examples of these vehicles and supporting technologies include

- Large UAVs such as Global Hawk and Predator
- Small UAVs such as DARPA's Miniature Air Launched Decoy, Micro Air Vehicle, and guided parafoils
- Land robotics for endgame mobility and sensor placement
- High-g tolerant electronics that can withstand the shock of gun launch or earth penetration
- Ultra-miniature electrol-mechanical systems that use the Global Positioning System (GPS) or inertial navigation systems (INS)
- Robust, jam-resistant systems that use GPS or INS

DARPA, AFRL, and others are developing such sensors and vehicles. Both the sensors and vehicles can enable new capabilities for the delivery of lethal and non-lethal systems. However, a cohesive project approach is lacking, and there is little apparent technology push from the technology base to the acquisition system.

Recommendation: Develop a class of low-cost sensors and air-launched or air-dropped vehicles for ISR, targeting, delivery of both lethal and non-lethal effects, and real-time BDA.

The Air Force should develop a set of close-access ISR sensors, delivery vehicles, and the related C^2 systems required to sense and engage the types of targets listed above in challenging environments. To the maximum extent possible, such systems should be developed with sufficient flexibility to allow for the broadest possible combinations of vehicles and payloads.

A broad range of unpiloted delivery vehicles and small close-access sensors can provide long-duration, low-cost ISR. A simple example is an air-dropped unattended ground sensor (UGS) that covertly sits near the end of a runway and sends a message via Orbcomm after each sensed takeoff or landing. The information obtained from such sensors can significantly reduce the workload for existing airborne ISR systems. This information can also be combined with lethal and non-lethal systems (perhaps delivered by the same new vehicles) to provide significant psychological and physical military effect.

This recommendation first and foremost addresses the unanimous observation that current ISR assets and their crews are stressed to the breaking point. In addition, this recommendation addresses the need to better operate, sense, and engage emerging target classes (for example, deeply buried targets) in potential future environments (for example, urban, chemical, and biological threat areas).

It is recommended that the Air Force develop a coherent program to exploit existing sensing and C^2 technologies as well as unpiloted delivery vehicles (to include unpiloted precision delivery vehicles which might be dropped or launched from manned platforms). To the maximum extent possible, the sensors and vehicles should be designed with standard interfaces (that is, "plug and play") so that flexibility is maximized. Sensor technology is maturing at a rate generally greater than vehicle technology. Plug-and-play architecture will allow future systems to be implemented without requiring major deployment vehicle redesign.

4.3.4 Finding: Timely indications and warning and response to terrorism and transnational threats place unique demands on ISR policy and capability.

Transnational and terrorist threats know no national boundaries and require global scrutiny. The threats are broad in nature and embrace ingenious employment of high explosives; nuclear, biological, and chemical (NBC) weapons; and cyber attacks. In each case, classic I&W indicators, for example, force deployments, weapons readiness, and defensive preparations, typically will be absent. Inside knowledge of the hostile decision and preparation process is highly desirable for obtaining sufficient warning time for preventative action, but is generally absent. Thus SIGINT can be a critical adjunct to high-risk human penetration. Improvement in sensors and sensor platforms is essential in detecting and monitoring NBC preparations (for example, weapons development, training, and dry runs) and for intercepting deployment and execution actions. In all instances the timelines for I&W are likely to be greatly shortened over the pace of conventional war preparations.

While prevention is clearly the goal, reaction may be the reality. Effective reaction can minimize the effect of the hostile action, identify the perpetrators, and prevent hostile follow-up actions. Attribution and attack assessment are immediate intelligence tasks. The need is to significantly improve the timeliness and scope of the intelligence (information) process in confronting a class of threat that can be global in origin, time-compressed in generation, and source-obscured in execution. In the case of computer network attack, the aggressors loop and weave through multiple systems before reaching an intended target, masking their identity and confronting us with national and international legal constraints.

The threat with which we are least familiar is that of cyber attack. It is this threat that caused Gen Ronald Fogleman to observe that, "While we fight in a theater, information warfare [cyber attack] will force us to be engaged worldwide. And so, we must have some good advice as we pursue this capability."

The I&W process, with respect to Information Operations, comprises

- Looking for evidence of doctrinal development
- Identifying key personnel, facilities, and agencies
- Assessing weapons possession or development
- Evaluating exercises of offensive capabilities
- Clarifying defensive information warfare capabilities, plans, and vulnerabilities

I&W in support of the information operations (IO) threat must contend with too few sensors, which are manpower intensive and not coordinated for information fusion, while attempting to address threats from nation states as well as nonnations and criminals. Locations are virtual, and resultant identification is transformable or masked by multiple hops in cyberspace. Collecting data to characterize the threat is difficult, if not impossible. Warning time is reduced to nanoseconds across the net for every target.

The tools being used are confined to those deriving from hackers and Internet experts, not from Air Force research and development. Furthermore, the domain being searched for threats is confined to only some DoD systems rather than the entire national security infrastructure (government and commercial), including the national information infrastruture. Hence, little is known or detectable of vulnerabilities, hostile targeting, and strategy.

Recommendation: Address legal issues and identify indicators, ISR platform, and sensor capabilities to enable timely indications and warning of transnational threats.

AIA should be tasked to provide Air Force leadership within the intelligence community in forming a structure and process focused on the unique demands of aerospace I&W for transnational and terrorist

threats. The effort should identify appropriate indicators, necessary ISR platform and sensor capabilities, and needed changes to the intelligence TCPED cycle, and address national and international legal constraints.

In addition to the straightforward military tasks of ensuring appropriate personnel skills and initiating development and subsequent acquisition of required sensors and platforms, there is a need to cooperate with law enforcement authorities to generate clear guidance for DoD to work within legal obstacles, both unilaterally and in described concert with law enforcement authorities.

The Air Force contribution to I&W is generally deficient in timeliness, threat source attribution, determination of both threat tactics and doctrine, and vulnerabilities to be targeted. A further impediment in an IO context is the imprecision and uncertainty in legally defining "acts of war" and the "state of war." Present-day technology to ascertain computer system intrusion is still in its infant stage and deserves considerably more attention and programmatic support. Furthermore, current technology that is capable of chemical and biological sensing is poor to non-existent, and though technology is available to sense nuclear presence, its application is selective and can probably be circumvented. A standoff capability is likewise poor to non-existent.

We recommend the aggressive development of sensors for both *in situ* and standoff detection and location of NBC weapons, associated agents, and precursors. Likewise, we recommend the acceleration of development and deployment of UAVs and air-droppable platforms for SIGINT collection and reporting. In the information system intrusion arena, the Air Force needs to significantly increase its efforts in developing software tools for detecting illicit attempts to access secure and protected systems, recognizing the enormous volume of legitimate traffic that should not be hindered. For the purpose of tracking targets, the Air Force should pursue measures and signals intelligence- (MASINT-) like technology, including tags and UGS. And finally, the Air Force should work to refine the intelligence I&W process and integrate with law enforcement authorities to share technology, information, and training, consistent with law, policy, and directives.

The Air Force Cyberwatch program executed from AIA should be built upon technology investment and be supported in efforts to broaden our national commitment to IO I&W.

4.3.5 Finding: The current intelligence cycle for tasking, collection, processing, exploitation, and dissemination is inadequate for OOTCW.

Discussion and Overall Recommendation

Traditionally, the intelligence cycle is sequential and oriented toward particular systems and security compartments and isolated from the C^2 environment. During the Cold War, with the world in a bipolar state, this approach was a significant component of the "big win." For the foreseeable future, however, U.S. forces will often have to deploy rapidly to areas where little *a priori* understanding of the threat environment, civilian disposition, leadership intentions, and infrastructure may be available.

Operations, such as in Somalia, serve as good examples of the shortfalls of the current modes of interaction between ISR and operations for many of the missions that will confront the United States in the future. ISR information was prepared according to assumptions of the operational details, and the operational plans were developed according to assumptions of the ISR details, in a non–time coincident manner. As a result, information critical to operational success was often placed in the hands of the warfighter who was out of synch with the operation. Many of the delays were associated with the asynchronous, compartmentalized, separate management of the force structure and ISR assets. This was further exacerbated by the lack of an interoperable information infrastructure and communications network. In the end, operational commanders were forced into action without the full benefits of our current technology. Lessons from this operation, combined with yet additional advances in technology,

motivate us to advocate a concept where ISR and force management are integral to each other—not just "interoperable"—and stand on a consistent information infrastructure, communications, and networks foundation.

Recommendation: The Air Force should take the initiative and lead the development and deployment of an integrated ISR-C^2 information management system (IMS).

OOTCW require levels of responsiveness and agility in the acquisition, assimilation, and delivery of information that are inconsistent with rigid cycle structures and demand a framework that is intrinsically dynamic. A shift from the traditional ISR cycle to an information system that is responsive to the new "intelligence warfighter" is mandatory if EAF is to succeed. The integrated ISR-C^2 IMS process should be a fully-integrated component of the C^2 system. From the warfighter's point of view, the specification of a commanded action—ranging from mission definition, to course of action specification, to the issuing of an air tasking order (ATO), to effects assessment—has associated with it clearly identifiable information needs to which the IMS process should respond automatically and effectively. It is useful to think in terms of the "handling qualities" of the IMS process: when an information need is presented to the information management process, the fulfillment of that need should be as direct and easily controlled as the direct tasking of a specific asset that is "owned" by the warfighter.

The Air Force should task the AC2ISRC to articulate the vision of shifting from the intelligence (TCPED) cycle to an IMS-based process and to define the operational architecture and functional requirements for the IMS. Figure 4-6 depicts the contrast between the current and recommended approaches. On the left, the current compartmented systems are represented; while on the right, the new integrated process is illustrated by overlapping circles integrally related with force management. Historically, a military decision notification is sent both to the force commander and to the set of stovepiped collection managers. As part of the overall planning cycle, the commander then informs the collection managers of the information needs. After this coordination point, the stovepiped collection management processes proceed independently of each other and of the commander through the TCPED cycle. At the same time, the commander proceeds with defining of desired effects, tasking weapon platforms, and executing the mission. As information is disseminated, it is provided to the commander; but there is limited possibility for dynamic feedback between the commander and the collection manager as the mission evolves and significant changes are detected or contingencies are encountered. In contrast, the IMS process, illustrated on the right, involves a completely integrated, collaborative environment, with information needs dynamically defined in response to the evolving military situation and the new intelligence warfighter.

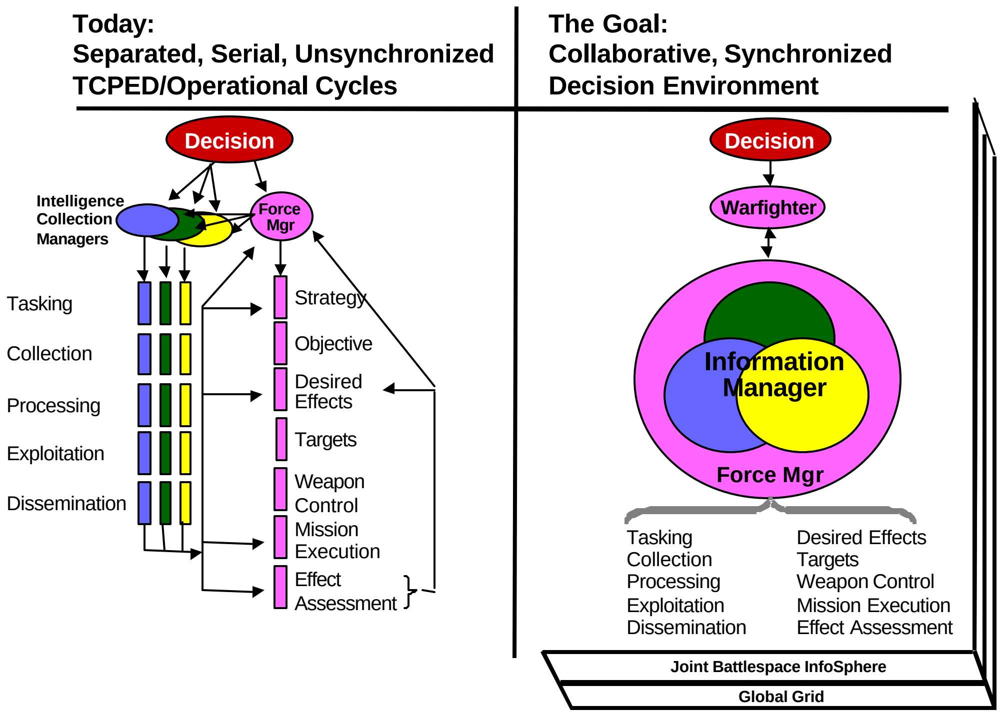

Figure 4-6. *Paradigm Contrast*

The warfighter needs to have the information in a timely and tailorable manner through a structured process and infrastructure. Comprehensive, dynamic, and near–real time knowledge bases about the diverse threat areas must be available to the warfighters with the ability to refresh rapidly. This process requires technology that keeps the information base current, accredited, and readily available to the decision makers as well as to the shooter. The goal of this recommendation is to create and deploy a collaborative, synchronized decision environment for the warfighter, making the IMS and battle management processes integral elements of the same overall system. This integration is essential for our forces to strike where needed, with the right ordnance at the correct time for the desired effect.

The panel recommends that the Air Force pursue the following actions:

Commit to the move to the IMS. The IMS process can be realized only if the U.S. Government reaches for the goal of a real-time intelligence and knowledge-based environment that is integral with battle management activities. The panel recognizes that a change of this magnitude will require significant technology development, as well as cultural and structural changes, and consequently will take shape over an extended period. The following three steps are recommended:

- Step 1: The AC2ISRC Chief of Staff should refine the vision and define the operational architecture functional requirements and implementation roadmap
- Step 2: The SAF/AQ should pursue development and deployment of Air Force–owned elements of the roadmap
- Step 3: The Chief of Staff of the Air Force should lead a joint DoD and intelligence community initiative for the development and deployment of the IMS, using the JBI concept and Global Grid initiative as the foundation

AC2ISRC Focal Point. With the AC2ISRC, the Air Force has a unique opportunity to harness and focus Air Force R&D investments in the technologies needed for the IMS process. In particular, in addition to the Air Force charter explicit in its name, AC2ISRC is instrumental in C^2 spiral development programs and is integral to the yearly Expeditionary Force Experiment. We recommend that AC2ISRC be explicitly identified and tasked as the organization responsible for coordinating with other services and intelligence organizations and for demonstrating the IMS construct through a spiral development process. Not only will this provide focus and a clearly identified customer for 6-2 and 6-3 efforts at such places as AFRL and DARPA, but it also will provide a common reference for identifying critical technology shortfalls that require contributions from Air Force Office of Scientific Research (AFOSR) and other basic research organizations.

Initiatives for Information Technology Investment. The following are the five critical technology areas (to be pursued by AFRL) requiring investment and the coordinating presence of the AC2ISRC:

1. **Representation of information** tailored to multiple-user needs, with explicit representation of uncertainty and ambiguity
2. **Information fusion** from track fusion to force structure analysis, including anomaly or change detection and data mining
3. **Dynamic allocation of assets** in response to needs of varying priority and urgency, and consistent with dynamic and military constraints
4. **Interaction with the user** through a high-level query structure with embedded and integrated sensor and force structure tasking, presentation of information and tools for user manipulation, and easy collaboration with other users
5. **Performance assessment** with measures of effectiveness and "handling qualities," and tools for planning and assessing the impact of new sensing concepts and operations

Discussions of each of these technology areas are provided in Section 4.4.

Joint Battlespace InfoSphere and the Global Grid. We recommend that the information infrastructure envisioned in the JBI study, together with the communications infrastructure in the Global Grid initiative, be used as the foundation for realizing the IMS process. We view the convergence of our study and these other initiatives as a real convergence of technologies that needs to be kept in clear view to avoid fragmenting technology efforts in the already fragmented information management and communications arenas.

Training. The dynamic and collaborative IMS structure requires not only that the individuals engaged in these functions feel confident that they are all working with a common operating picture, but also that they have the training required to exercise their responsibilities in this interactive environment. We recommend that AC2ISRC develop training concepts and methods that match the IMS process as it is developed.

An Example

In this section, we provide a brief description of a military scenario that illustrates the nature of the information needs and responsiveness required by warfighters, how these needs map onto IMS functions, and finally how these functions map onto the five technology areas listed in the previous section and described in detail in the next section.

The scenario involves the deployment of a B-2 bomber from the continental United States on an operational mission. Once the aircraft is launched and en route, optimizing mission execution requires and responds to ISR-generated information provided through the Integrated ISR-C^2 IMS. In particular, decisions concerning mission execution might include any or all of the following:

- Alternate refueling options
- Target selection
- Weapon selection
- Rules of engagement guidance
- Abort instructions
- Attack and egress routes
- Altitude
- Recovery location

Making these decisions requires information on numerous aspects of the military situation including

- Current and dynamically changing enemy defense dispositions (ground and airborne)
- Target identification and precision tracking
- Updating of the military value of the designated target in response to changes in the military situation and the identification of other targets of opportunity of potentially greater military value
- Collateral damage probabilities
- Environment (weather and terrain)
- Overall situation awareness

In order to provide this information, the IMS has at its disposal a variety of information sources, including not only the common operating picture that dynamically maintained within the JBI, but also a dynamically varying set of sensing assets, potentially including the following:

- National assets that may be over the theater
- Airborne assets that may be taskable to survey the region of interest to the mission
- In-place or real-time deployable sensors (UGS and micro-UAV sensor platforms)
- HUMINT sources provided by forward and special operations forces

The role of the Integrated ISR-C^2 IMS is to manage all of these sources to provide the information required for mission execution in near–real time, in response to interactive information requests from the relevant warfighters (that is, the pilot, mission planner, and, perhaps, higher-level decision makers). Achieving this requires the following:

- High-level user interface so that the initiation of the B-2 flight triggers information need requests as described above.
- Fusion of available information within the JBI in response to these information needs and the identification of gaps in the required information.
- Dynamic and optimal allocation and scheduling of sensing assets to fill the identified information gaps. The dynamic resource allocator must automatically deconflict the fulfillment of these needs with other information tasking requests associated with other actions in theater and must notify the force managers quickly if complete deconfliction is impossible.

- Presentation of the required information, including pinpointing significant uncertainty or ambiguity in that information, which can trigger further information requests to reduce uncertainty or ambiguity. For example, ambiguity in the identity of a particular object along the planned flight path may lead the warfighter to request clarification using any available asset (for example, the type of intelligence to use and type of asset—national, airborne, or deployable) that is capable of fulfilling the specified information need.
- Initiation of monitoring processes to detect changes in the situation—for example, in an enemy defensive structure that threatens the B-2 or in a military situation that affects the relative value of different targets. This can include both additional allocation and scheduling of sensing assets and the insertion of standing queries into the IMS for alerts on changes in specific aspects of the military situation. In particular, the fact that a B-2 will be in theater should initiate an automatic request for notification of newly identified high-value targets that are appropriate for the B-2.
- Presentation of information associated with an alert (including uncertainty and ambiguity) so that the force manager can decide whether trajectory replanning or retargeting is required.

Table 4-3. *Mapping of IMS Tasks to the Critical Technologies*

	High-Level User Interface	***Fusion of Available Information***	***Dynamic Allocation and Scheduling***	***Presentation of Information***	***Initiate Monitoring Process***	***Presentation of Alert Information***
Representation of Information	X			X		X
Information Fusion		X			X	
Dynamic Allocation of Assets			X		X	
Interaction with User	X			X		X
Performance Assessment			X		X	

4.4 Discussion of Relevant Technologies

4.4.1 Representation of Information

The design of the data structures to be used for the IMS is a challenging problem for at least four reasons. The first is the requirement that the structure be capable of dealing seamlessly with the high-dimensionality, heterogeneity, and multiple granularities of the information either directly provided by the full suite of ISR resources or required as information products by users of the IMS. There are multiple dimensions of information and context over which the IMS and the users must reason: 3-dimensional space, time, the organizational structure of objects and entities (including transportation and communication connectivity and command hierarchy) and the current activities of different objects and entities. Moreover, there are different granularities of information in all of these dimensions. For example, spatial resolutions provided by different sensing and information assets can vary significantly, and the resolution requirements for different military functions (for example, from mission planning to precision targeting) can also be quite different.

Similarly, the level of knowledge required about individual objects may vary from the planner's understanding of the relationship of that object to the overall enemy force structure to a pilot's knowing whether the object presents a threat to the aircraft. Moreover, all of the dimensions of the information

space interact dynamically. For example, terrain and road network connectivity present constraints on the motion of particular types of objects, implying both that particular motion patterns may provide information about target identity and that knowing the target identity may help in enhancing track accuracy for that target because of implied constraints on its possible motion.

Second, the representation must facilitate the assimilation of data from a wide variety of sources, each of which provides quite different "apertures" into the information space. For example, a moving-target indicator (MTI) radar provides spatial and temporal information and possibly some information that can be used for target typing (for example, whether the radar also has a high-resolution mode). A SIGINT sensor can provide different information useful for target typing as well as for spatial-temporal information with quite different resolution and accuracy.

As we see it, the operation of assimilating information into the information space involves at least three distinct functions. The first is *populating* the information space. For example, in the JBI concept, the instantiation of a JBI begins with a phased process of pulling relevant archived information into the JBI and establishing broadly-defined information needs depending on the mission type and other factors. Roughly speaking, this is a process of information intensification in which a framework is established and an information backbone is initiated, and the data structures used in the IMS must make this process efficient. In the second assimilation function, referred to as *updating*, new information is used to improve the accuracy or currency of information objects already in the IMS. This is distinguished from the third function of *fusing* information—although the boundary between these is indistinct and possibly artificial. Information *fusion* refers to the process of providing either *new* information objects or *augmented descriptions* of existing objects through the combined use of information from disparate sources. For example, by combining an MTI track with SIGINT information and possibly with SAR imagery if the object stops, the Air Force may be able to associate a target type with that object. Similarly, by analyzing the motion and emission behavior of a group of objects, the Air Force may be able to associate all of the objects with a coordinated activity, which in turn may help with the identification of individual objects within the group.

What is absolutely critical about all of these assimilation operations is the fundamental fact of information fusion: **The need for information fusion implies that, prior to fusion, the information available is incomplete, imperfect, and uncertain.** The unavoidable conclusion is that the representation of information in the IMS requires the specification of the ambiguity and accuracy of that information in a way that makes fusion meaningful. This specification can include the pedigree of particular pieces of data, but it typically will involve much more than that. For example, the fusion of MTI, SIGINT, and SAR may narrow a target type down to a small number of alternative types rather than a unique identifier, and capturing that ambiguity is essential if future information is to be fused and interpreted correctly.

The third major issue is designing the data structures for the IMS to deal with the user. In particular, different users will demand very different apertures for the information space and will have very different queries. The nature of military C^2—including the desire of providing the warfighting decision-maker with the handling qualities and responsiveness he or she needs—suggests queries and query structures that differ dramatically from standard information databases. Consequently, there is a highly nontrivial technical challenge to develop data structures that support military information needs.

Finally, a very important requirement is that the information representation be designed so that the nature of information that is either collected or requested will evolve in the future as new sensing technologies are developed and new types of contingencies are encountered. Thus, while the chemical composition of the exhaust from a vehicle might not be useful or measurable today, the data representation adopted should be flexible enough to include this information if it does become important in the future. Accommodating such information should not cause a cascading array of changes throughout the information architecture.

4.4.2 Information Fusion

Information fusion is a simple concept: several uncertain sources of information are combined to produce a fused object with reduced uncertainty. Events present in the new information may be significantly inconsistent with the previous state of knowledge and thus represent anomalies or changes not captured by the previous situation model. Adopting any self-consistent information or uncertainty calculus (for example, using probabilistic models and methods) would then seem to provide a straightforward way in which to build a fusion engine that is self-consistent and optimal with respect to the processing of information and the management of uncertainty. The problem is that the complexity and heterogeneous nature of the information space—including all of the dimensions mentioned previously and all of their interdependencies—makes such a naïve application of the rules of information calculus intractable (by enough orders of magnitude to make it impossible even in the 31st century) and undesirable, as it neither exploits nor exposes the structure of military situations.

However, what such a naïve approach does do, thanks to its self-consistency, is to guarantee that fusing several sources of information always reduces uncertainty and hence provides a more reliable estimate of the state of the battlespace. That this absolute statement about fusion is not understood nor accepted uniformly throughout the military community is a result of the fact that fusion systems developed with a primary aim of computational tractability do not necessarily produce results that make things better. Consequently, the fundamental challenge is to develop an information fusion architecture and associated algorithms that can deal effectively with the complexity of reasoning and fusing information over space, time, and hierarchy in a manner that exploits and exposes the structure of military situations and that also is guaranteed to always produce products that are better than any of the constituent raw materials on which it operates.

Meeting this challenge requires the development of technologies in a number of related topics. First, there is the design of fusion architectures: how can the hierarchical and spatio-temporal structure of military situations be exploited to decompose the fusion problem into a network of smaller, more focused fusion problems of tractable size but still of military significance? There are obvious ways in which this can be done and that are now done in military information systems, but a critical issue for fusion processes appropriate for the JBI is to make sure that these fusion processes interact in a consistent manner. For example, from the point of view of one fusion process, the inputs provided to it may include not only new sensor data with known resolution and accuracy (that is, the "sensor specs") but also products of other fusion processes. Fusing such derived products in a consistent manner that guarantees that fusion adds and does not subtract value, requires that the fidelity of fused products also be available.

Examples of components of a problem decomposition of an overall fusion architecture are myriad, and the following are included simply to illustrate the types of issues that must be considered. A first such fusion problem is that of fusing multiple target track information from multiple sensors, incorporating what is known about target types, road networks and terrain, and target activity. For each of these sources of information, the fusion engine must have (or must derive) associated measures of quality and accuracy. For example, if one source of information consists of AWACS tracks, the associated track accuracies are an essential part of the input to the fusion process. Similarly, if higher-level information or fusion processes provide information on target organization and coordinated activity, any ambiguity in this knowledge must be captured.

A second fusion process is such a higher-level activity reasoning process. For example, the concepts of motion pattern analysis and behavior pattern analysis refer to the process of taking fused track information (for example, from the fusion process just described) and analyzing it to produce one or more likely hypotheses for the organization and activity of a group of objects. Obviously for this higher-level fusion process to be effective, the accuracy of the fused input tracks needs to be specified. Moreover, these two examples of fusion processes point out the absolute need for consistency, as each of them takes

the outputs of the other as its inputs. It is easy to imagine that without a principled approach to capturing the pedigree and accuracy of the information provided to and produced by each fusion engine, the result of coupling these two fusion engines could very well produce the "Chicken Little" effect in which the evidence accrual process internal to each fusion engine hears that the "sky is falling" from its neighbor and interprets it as corroboration rather than simply as a parroting of the message that it had previously sent out itself.

In addition to the information-theoretic function of fusing information in a consistent manner, each fusion process also has embedded in it the function of detecting significant inconsistencies, anomalies, and changes. Indeed, the notion of *significant* again underscores the importance of maintaining measures of accuracy and pedigree in the information objects embedded in the IMS. These measures of uncertainty then provide dynamically varying yardsticks with respect to which fusion processes can assess whether a new piece of information is within the accuracy limits of our current estimate (in which case the fusion process proceeds with standard fusion or updating) or is outside those limits, signifying an event requiring action other than standard fusion.

Designing algorithms to perform such anomaly detection tasks represents another part of the technology development program associated with this recommendation, as does the development of algorithms and tools for analyzing the nature of an anomaly and incorporating this analysis as an update to the information state in the IMS. The nature of such analysis tools, however, can vary widely, ranging from simple alerts to operators who investigate the anomaly and then manually enter the updated information state to fully automatic algorithms that extract the new information state from the data. For example, if the information state of the IMS indicates that there are three objects in a particular area but a new SAR image shows four objects, an automatic algorithm could be used first to associate three of the four objects with the ones previously in the IMS state; second, to update the information on these three objects to incorporate the information extracted from the SAR imagery; and then to instantiate a fourth new object for the newly detected target. As a second example, suppose a group of vehicles under tracking have been identified as being collectively engaged in a specific activity, and suppose that new MTI data are received that show motion of some of the targets that is inconsistent with that activity. In this case, an analyst might be alerted to examine the situation in order to redefine the activity hypotheses associated with the group of targets. For tasks such as this or others that involve the discovery of previously unseen phenomena or behavior, tools from emerging technologies such as data mining are likely to play a significant role.

Finally, it is important to point out that there are additional challenges in information fusion if it is to be carried out, as it certainly must be, in a distributed environment. In particular, keeping track of pedigrees and coordinating information flows in order to avoid "Chicken Little" becomes much more complicated if there are concurrent fusion operations on multiple platforms, which involve exchanges of information between platforms as well as overlapping sets of intelligence data. Of course, consistency in distributed databases has been recognized as a critical technology topic for some time, and emerging distributed database technologies are undoubtedly relevant to the military information fusion task. However, there is now a need for another level of consistency, namely an information-theoretic consistency. It is not enough for the information states in such a distributed environment to agree; they must also maintain a consistent picture of the pedigree of the information in each node of the networked environment so that subsequent fusion operations correctly interpret the added value of information passed from node to node.

4.4.3 Dynamic Allocation of Assets

Central to the recommendation for replacing the rigid and open-loop TCPED cycle with an IMS is the idea that sensing, collection, and even processing assets need to be allocated dynamically in a manner responsive to information needs articulated by the users of the IMS. Much as the modern pilot has virtual rather than direct control over some of the control surfaces on an aircraft (with the flight computer

providing the mediation between pilot commands and surface actuation), the panel envisions a future system in which the warfighter may have virtual control over sensing assets—rather than rigid ownership of specific sensing assets—with the IMS playing the role of mediator and scheduler of a suite of assets to meet the combined needs of all of its users.

What this implies is the need to develop large-scale dynamic planning and resource allocation algorithms capable of dealing with dimensionality and complexity that match those of the information fusion function. In particular, a dynamic collection management system must deal with information requests from multiple users. In addition, requests may differ in terms of overall priority, required timeliness, latency, resolution, and accuracy. For example, BDA will have more relaxed timeliness and latency requirements than precision targeting information. Similarly, sensing requests associated with pinpointing surface-to-air missile (SAM) sites in connection with a particular ATO have hard timeline constraints coupled with the flight plan of the associated aircraft. Information requests arrive asynchronously so that highly time-critical and high-priority requests may arrive subsequent to lower-priority tasks, requiring that the scheduler have the agility to replan dynamically. In addition, the scheduler must deal with a heterogeneous and dynamically changing set of available sensing assets, such as AWACS, JointSTARS, and U-2 aircraft, which may be ready and available, on orbit, or in maintenance; UAVs, which may be available for launch or may be diverted from current locations; deployable or disposable microplatforms; and UGS. Each of these sensing platforms may have several different sensing modes (for example, MTI, high-resolution radar, or SAR) and also may have very different delivery dynamics that constrain the interval from the time at which the asset is scheduled until the time it is in position to provide the needed information. Moreover, the threat environment (for example, locations of SAM sites) provides additional constraints on feasible asset deployments.

As with the information fusion problem, at the naïve level there is a clear solution methodology for this resource allocation problem: it is a large-scale mathematical optimization problem. However, again as with the information fusion problem, the solving of this enormous problem in one large bite is neither computationally feasible (it is very easy to construct modest resource allocation problems with solution search spaces that exceed the cube of the number of atoms in the Milky Way) nor desirable. As a result, there is a clear technology need, namely the development of effective scheduling algorithms that are scalable to problems of the size that will arise in military operations.

4.4.4 Interaction With the User

The panel envisions IMS as an information services process serving different warfighters with differing information needs. A critical issue is the development of an information query system that allows the user to request precisely the information needed for his or her immediate objectives. The query structure should allow the user to enter information requests at a very high and, perhaps, implicit level. For example, if we think of the IMS as an embedded system within a C^2 system—that is, as a component of a very large and complex servo loop—then the query might actually be simply the statement of a particular mission, with the embedded information needs implicit in the mission statement. For example, when an ATO is specified, an entire sequence of information needs can be defined, including when each piece of information is needed: information about terrain and enemy activities along the flight path, locations of potential SAM threats, detailed information about the target and its immediate information (for example, imagery, information about nearby neutrals, friendly forces, or hostages), and finally, BDA information after ATO completion.

An important point to note about the preceding example is that while some of the embedded information requests associated with the ATO involve information that may already be available within the IMS (in the form of maps and SAM site locations), other pieces of information will certainly have to be collected on the fly (through detection and location of enemy aircraft, precision targeting, and BDA). Thus, implicit in this very high level information query are information collection requirements, which must be

fed to the sensor scheduler so that the information is collected when it is required. At this high and idealized level, however, all of this would be implicit and embedded in the IMS and would be as invisible to the user as are the internal calculations in a flight computer when a pilot commands a maneuver. Of course, one can also imagine much lower level query structures in which the user must specify each individual information need and when it needs to be provided, but the ultimate objective should be to strive for an "information search engine" that minimizes the need for the user to dissect his or her overall objective into subtasks.

The panel also believes that it is important that the query structure allow for the easy specification of specialized queries related to particular contingencies that require exceptionally fast response cycles—for example, that may, if appropriate, short-circuit much of the information digestion process in order to close the sensor-to-shooter loop expeditiously when a target of interest presents a transient window of visibility or vulnerability. Given the substantial downside of sending erroneous trigger signals to a shooter, a specialized query requires special processing. In particular, in the parlance of decision theory, such a query specifies a sequential decision theory problem in which there is a tradeoff between delay in action and the possibility of acting according to a false detection. For most military decision cycles, that tradeoff must be under the complete control of the warfighter. However, if very rapid responses to transient opportunities are envisioned (for example, a Scud launcher is spotted moving in the open or a terrorist or enemy commander is spotted at an unhardened site), the Air Force may need to include queries that in turn require the development of technology either for fully automatic detection and response or at least for the presentation of decision aids (for example, the probability that a detection is real or false or the expected time interval of opportunity) to the warfighter to shorten his or her decision cycle.

In addition to active information requests by users, it is clear that there is also a need for mechanisms for an information push to the user—for example, alerts to the user that something has changed in an area of regard or an activity of importance. Advanced Web browsing applications provide services of this type—for example, alerting a subscriber that something has been added to or changed from a Web page designated by the subscriber. Analogous services are certainly required for the IMS, where there are at least two dimensions of technology challenges beyond those encountered on the Web. First, the information state of the battlespace changes continuously, and thus there is the need for decision logic for detecting significant changes that warrant a user alert (this is the anomaly detection problem mentioned under "Information Fusion"). This is another challenging problem in sequential decision making: how to trade time delay in alerting the user with the "cost" of false alarms with the user's ability to perform his or her function? Second, there is the question of how a user specifies the areas in which he or she wishes to receive alerts. This is closely coupled with the choice of information representation that is adopted, as significant anomalies may involve information in any subset of the dimensions of the information space.

Another important characteristic that needs to be incorporated into the query structure is user drill-down into the database. One of the objectives of any information management process is to digest raw data and provide fused and higher-level products of direct use to the decision maker with minimal extraneous detail. However, it is unquestionably the case that the experienced warfighter will have capabilities for information fusion and analysis that are much more adaptable than available algorithms. Consequently, it is essential that the user have the capability to drill down into the IMS in order to see the raw materials that produced a fused product and, if necessary, to change that product. For example, if a user is presented with a spatial display of a number of targets, with IDs on each of these, the user should be able to pull up the SAR, SIGINT, or other data chips used for each target in order to assess whether the identification provided is correct or needs to be changed.

One technology area that the panel believes holds great promise for many of the issues raised here—and one that is finding use on the Web already—is that of intelligent agents. Agent technology is at a very early stage of development, but the concept suggests development of new types of algorithms to assist the user in interacting with the IMS. For example, consider the problem of defining information needs

associated with a specific ATO. There are two extreme cases that don't require the use of an agent as an assistant. One is to have a hard-wired protocol: The user enters the flight trajectory, timeline, and purpose, and this triggers a fixed set of information requirements. At the other extreme, the user alone determines each of these information requirements and their precise timing. Between these extremes, imagine an agent that adaptively learns what types of information requests are necessary under different conditions, perhaps prompting the user for particular details of the attack plan (for example, the altitude and speed for different parts of the segment and the time at which prosecution of the target is desired), then generating the precise sequence of information needs for the IMS. Similarly, intelligent agents can play a role in learning what types of alert information are important to the user and then use this information to initiate alert requests directly. The development of such algorithms allows agents to learn the critical elements of the user's decision space and then to use this knowledge to generate an information needs profile. At this point this is a vision rather than a reality, but it is a development that should be part of the technology investment strategy.

An additional technology need is the development of tools for presenting information to the warfighter. Advanced visualization methods are central to this, and emerging commercial and military technologies in this area should be exploited to their fullest. However, some specialized technology needs require significant extension beyond what can be expected from current or emerging visualization products. One major issue is the presentation of the uncertainty or ambiguity in the information state captured by the IMS. While it is easy to understand how one might put an error ellipse on a screen in order to capture the location uncertainty of a target, it is less obvious how one would present ambiguity in the identification of multiple objects, in the association of SIGINT or electronic intelligence returns with particular targets in a target-dense environment, or in the inferred organization of multiple targets into a force structure and set of activities. Furthermore, different users may require different spatial extents and different granularities of information (for example, a pilot will want very detailed information near the flight path but perhaps only general information about activities at a distance). As already mentioned, the interface must make it easy (say, with the click of a mouse) for the user to drill down into the database to see constituent data that went into the fused products displayed. Moreover, since the user can be viewed as a resource for performing difficult fusion functions, we can also envision the IMS prompting the user to drill down in particular areas to reduce ambiguity that the IMS cannot accomplish by itself. This suggests a nontrivial decision and scheduling problem. In particular, while an experienced human has capabilities for interpreting information with a speed and a manner that is not easily duplicated in an algorithm, the human also has a far more limited ability to consider multiple threads of information assessment simultaneously. Consequently, from the point of view of the IMS, the human appears to be a very adaptive but load-limited fusion resource, and scheduling the querying of that resource to take maximal advantage of its capabilities is an important but, to our knowledge, unexplored area of investigation.

4.4.5 Performance Assessment

For a variety of reasons, the panel believes it is essential that the development of the IMS or any other information management system for C^2 be coupled with the development of measures of performance (MOPs) and the means for their evaluation. Historically, performance assessment has been the poor sister in algorithm or system development, and, when resources become short, it is the first to be told that it can't go to the ball. We strongly believe that this is penny-wise and pound-foolish because performance assessment is needed for several reasons.

First of all, it is essential that MOPs be established that do what the IMS is expected to do. Certainly there are some measures for standard databases—for example, the time from query to result—but the panel strongly feels that these are inadequate for military C^2. Developing these MOPs, however, is by no means an easy task because the metric is not as simple as stating the amount of radar cross section reduction achieved by the use of stealth technology. Thus, MOP definition and methods of evaluation are technology needs. To that end, several types of MOPs are certainly needed.

First, there are the MOPs that the IMS needs for its own operation. As previously argued, each piece of the information state of the IMS must be accompanied by a measure of its accuracy, ambiguity, or uncertainty. Since most, if not all, of the information in the IMS is the result of the fusion of multiple pieces of information, a method is needed for quantifying the performance of a fusion process: given the uncertainties in its inputs, what is the uncertainty in its outputs? Similarly, the dynamic resource scheduler must have performance models as part of its internal structure. Given an information need, specified by type of information, timeliness, and required accuracy, the scheduler must first determine what sensing assets could meet the request, and this in turn requires performance models for how the data provided from each asset could fill the information gap in the IMS.

At a higher level, there are clear needs for system-wide MOPs. Returning to the notion of handling qualities, the panel believes that the intent in defining such MOPs should be to capture and articulate what those handling qualities are. That is, the Air Force needs to establish measures of responsiveness, agility, and reliability for the IMS. Having such MOPs not only will provide a rational basis for articulating what is gained by such a new information environment, but also allows DoD planners to ask "what if" questions—for example, how would performance improve if a particular new sensing asset were added to the arsenal, and how does that performance improvement contrast with just simply adding current assets?

Finally, here is a strong word of caution. To be sure, the current configuration of ISR systems—stovepiped rather than information-centric—represents a very suboptimal solution to providing warfighters with the information they need. However, the stovepiped structure that results, while limited in responsiveness and performance, is stable and relatively easy to understand precisely because of its structure. The goal of going to a network-centric, nonstovepiped architecture is to overcome rigid performance limitations. However, such transition also runs the risk of introducing instabilities that threaten the integrity of the entire system. Indeed, the history of adaptive flight control has several examples—the early adaptive control system in the X-15 is a classic one—in which the dream of enhanced performance led to designs that introduced instabilities not present in more ossified but well-understood classical control loops. The happy ending, of course, is that adaptive, digital flight control is the way of the world today, but to achieve that same happy ending for the IMS will require careful performance analysis and a rigorous experimentation plan.

4.5 Opportunities for Technology Investment

The panel believes it is essential that these technical challenges be addressed by the Air Force. Existing technologies for example, in database design and management, together with currently available and envisioned commercial capabilities, need to be the foundation for focusing science and technology investment. In addition, there are ongoing programs in which some of these issues are being considered, and the Air Force should include these emerging technologies as it plans its investment strategy. The following list represents some of the programs known to our panel:

- Dynamic Database (DARPA/Tactical Technology Office; managed by several organizations, including the National Imagery and Mapping Agency and AFRL)
- Adaptive Sensor Fusion (AFRL)
- High-Performance Knowledge Bases (DARPA/Information Systems Office; managed by AFRL, AFOSR, the Navy Space and Naval Warfare Systems Command, and the Central Intelligence Agency)
- New World Vistas—Global Awareness (subtopics managed by AFOSR Software and Systems) and Planning and Scheduling (managed by AFOSR Discrete Mathematics and Optimization)
- AFOSR Agent Technology Program (Software and Systems)

- Multidisciplinary Research Program of the University Research Initiative (MURI) on Mobile Augmented Battlespace Visualization (ARO and Office of Naval Research)
- Advanced ISR Management (DARPA/Tactical Technology Office)
- Agile Control of Military (DARPA)
- Far-Sighted Approaches to Sensor Management (AFRL)
- Discoverer II Sensor Resource Management (DARPA/Air Force/NRO)
- AFOSR Software and Systems Programs in Networked Systems
- Moving Target Exploitation (DARPA; managed by AFRL)

While each of these programs will provide technologies relevant to the challenges described, there is a significant need and opportunity to provide a focus for all of these activities, to facilitate transition of technologies, to provide a vehicle for spiral development, and to identify technology shortfalls that can be used to guide further technology development.

Table 4-4. *Contributions of Ongoing Projects to Technology Investment Areas*

	Representation of Information	***Information Fusion***	***Dynamic Allocation of Assets***	***Interaction With the User***
Dynamic Database	X	X		X
Adaptive Sensor Fusion	X	X	X	
High-Performance Knowledge Bases	X	X		X
New World Vistas	X	X	X	
AFOSR Agent Technology Program				X
MURI on Mobile Augmented Battlespace Visualization				X
Advanced ISR Management			X	
Agile Control of Military			X	
Far-Sighted Approaches to Sensor Management			X	
Discoverer II Sensor Resource Management			X	
AFOSR Programs in Networked Systems		X		
Moving Target Exploitation		X		

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Appendix 4A

Intelligence and Vigilance Mission Statement

The tasking to the Intelligence and Vigilance Panel was as follows:

- Identify unique and common ISR needs for OOTCW
- Assess current and planned capabilities of the Air Force, other Services, agencies, and commercial services against OOTCW needs and the staff-provided OOTCW vignettes
  - Include collection, exploitation, management, and dissemination of data from EO/IR, radar, SIGINT, HUMINT, MASINT, etc.
  - Investigate manned aircraft, UAVs, space, tags, UGSs, etc.
  - Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
- Postulate evolutionary and revolutionary concepts, options, and technologies for meeting shortfalls

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Appendix 4B
Organizations Consulted

33rd Fighter Wing

36th Special Reconnaissance Squadron

Air Force Research Lab

Air Force Special Operations Command

Air Intelligence Agency

Central Intelligence Agency

Defense Advanced Research Projects Agency

Defense Intelligence Agency

Electronic Systems Center

National Reconnaissance Office

National Security Agency

U.S. Central Command

U.S. Southern Command

U.S. Special Operations Command

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Chapter 5
Deployment and Sustainment

Amateurs discuss strategy—Professionals study logistics

Source Unknown

5.0 Deployment and Sustainment Executive Summary

5.1 Definitions

As the Air Force moves toward its vision as an Expeditionary Air Force (EAF), the importance of robust and complete deployment and sustainment systems increases. For the purpose of this study we define the following:

- **Deployment**: Preparing for, planning, and executing the movement of a military force to one or more operating locations, and establishing a base of operations
- **Sustainment**: Supporting and protecting the personnel and equipment of a military force to enable the conduct of operations

During the course of the study, the Deployment and Sustainment Panel visited a variety of customers and providers of deployment and sustainment services. The panel developed an understanding of the Air Force's approach to satisfying these needs. Much of the current Air Force program is well directed to solving deployment and sustainment problems. The panel's purpose was to identify problems and recommend solutions. While the focus of this study is technology, the study is not limited to technology. The panel often found that process or organizational issues overwhelmed anything that technology could provide.

Start Thinking EAF

The new EAF is being implemented initially with a revised organizational structure composed of 10 Aerospace Expeditionary Forces (AEFs) and 5 Humanitarian Expeditionary Forces (HAFs). Exercises are being defined to train and measure this new construct's effectiveness. The panel heartily endorses the move toward an EAF. However, the emphasis to date has been on combat forces, and the logistics dimensions of expeditionary operations have not received enough attention. The deployment and sustainment portion of the EAF should be developed in parallel with the other operational elements. These forces are part of the "high-demand, low-density" assets that the Air Force possesses, and they need to be treated that way. In particular, the nonmobilized contingency coupled with normal daily peacetime operations presents significant challenges to deployment and sustainment forces.

During virtually all of the Air Force's existence, it has been forward deployed with an expansive permanent base structure to support operations and life style. To implement the EAF, traditional thought processes must change. "Expeditionary" is a state of mind and is a new concept to many Air Force communities. The goal should be the capability to deploy mission-tailored forces anywhere they are needed and to rapidly establish operations. Especially in operations other than conventional war (OOTCW), this will often involve going to austere forward bases or sites. Recent AEF rotations to prepared bases are important steps, but are not representative of a fully expeditionary model. Only Red Horse, Special Operations Forces (SOF), and low-density, high-value assets (including transporters and lifters) are routinely expeditionary today.

A valuable lesson can be learned from the U.S. Marine Corps. The Marine Corps is 224 years old, but it became an expeditionary force only after the Korean War. Some major changes had to take place. Until the force became expeditionary, there were two primary military occupation fields in the Corps: infantry and aviation—now there are three primary occupational specialties in the Corps' main stream: infantry, aviation, and *logistics*. Each of these is equal to the others in quality, funding priority, and every other aspect. Logisticians in the Air Force must have more influence in decisions, and that will bring better discipline to deployment and sustainment operations. A cultural change is required. The Air Force should study the Marine Corps' transition into an expeditionary force for valuable lessons.

The expeditionary concept requires strict discipline. Tables of allowance and authorization for squadrons with the same aircraft type must be standardized. Unit "ownership" of equipment must be subordinate to efficient expeditionary operations. To avoid overwhelming the logistics system, the Air Force must think in terms of rotating only personnel on a regular basis, not all their associated equipment. Heavy equipment packages should be readily transferred between units rather than making two-way moves around the world.

OOTCW consume the majority of the day-to-day, month-to-month, and year-to-year Air Force tasking. However, forces are sized according to two nearly simultaneous major theater wars (MTWs), and the assumption is made that these forces will then be adequate to conduct all smaller operations. The weakness in this process is that different forces are available. In an MTW, mobilized forces are available from the Air Reserve components (ARCs), the Air National Guard, and the Civil Reserve Air Fleet (CRAF). During OOTCW the active duty force bears the brunt of the tasking. For cost and political reasons, the ratio of the active forces to the ARC has decreased from 1.4:1 to 0.6:1 (or from more than 5:1 to about 2:1, counting only strategic airlift) during the past decade. Figure 5-1 describes the problem in the way forces are sized. Fundamentally, there is no relationship between the forces servicing the day-to-day OOTCW demands and the sizing methodology for the forces conducting those operations. Airlift forces should be sized by components according to the more challenging of OOTCW or wartime requirements, whichever is greater. The panel expects that the OOTCW requirements would justify increased active duty mobility aircraft and crews.

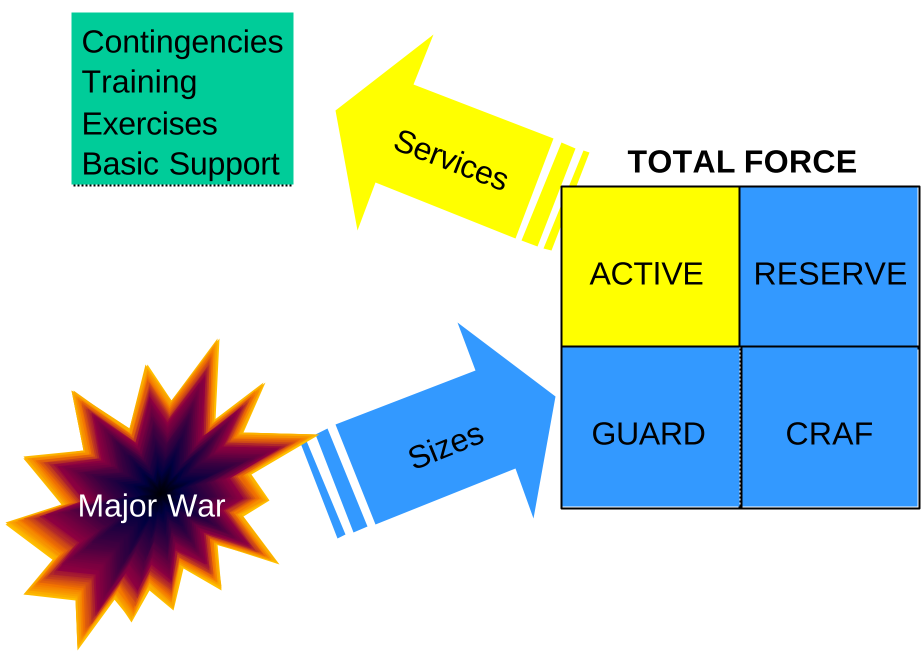

Figure 5-1. *Force Sizing*

For a variety of reasons, training and exercises routinely ignore significant parts of real operations. The focus of today's Air Force exercises and training is typically major combat operations and does not fully address logistic issues. For example, most exercises start at the beginning of hostilities instead of at the planning, execution, and deployment phases. Many problems in OOTCW are associated with deployment and sustainment—issues also routinely ignored or assumed away in exercises and training. It is a fallacy to believe that all other missions are simple subsets of MTW and thus covered by this preparation. The Air Force needs to ensure that OOTCW considerations are included in all training and exercises.

The panel strongly supports the effort of the Air Mobility Warfare Center (AMWC) to establish an Air Mobility Battlelab (AMBL). The Air Force should incorporate the AMBL into its official battlelab structure along with the other battlelabs.

If the Air Force is serious about transforming itself into an expeditionary force, it will require a paradigm shift that touches all areas of the force.

Address Logistics in Every Phase of Global Engagement Operations

The Air Force is moving toward adoption of the Global Engagement Operations (GEO) construct as a strategy-to-task framework. The phases of GEO reflect both the expeditionary model and the changing role of American military power in the emerging global security environment. The combat force's culture is apparent in the functional breakdown of GEO. The emphasis in GEO to date has been on the operational and strategic aspects of future aerospace force applications. A better balance between combat and combat support is needed. Explicit acknowledgement of logistics functions must be included in GEO elements and functions during Shape, Respond, and Reshape phases. Some of the more important logistics processes and considerations are as follows:

- **Shape.** Forces designated as prime for deployment for MTW or OOTCW must have their logistics status brought to and kept at full readiness. This includes filling readiness spares packages (RSPs), ensuring full support equipment inventories, properly managing aircraft phase inspections and many other activities. Tanker and airlift assets must be postured (for example, by establishing tanker task forces at staging bases) to support deployment timelines. Mobility en route and theater infrastructure should be improved; the Deployment and Sustainment Panel recommendation to proceed with Regional Contingency Centers (RCCs) is especially important. Training and exercises must realistically incorporate mobility and sustainment. Deployment databases must be constantly updated to support crisis action planning.
- **Respond.** Fast, integrated crisis action planning, supported by current data and incorporating logistics feasibility analysis, is critical at the start of any operation. The air bridge and in-theater airheads must be rapidly established and complemented by cargo forwarding to theater delivery points. As the deployed force is established, it requires agile combat support (ACS), including reachback, time-definite delivery of personnel and materiel, retrograde transport of personnel casualties and failed equipment, and a robust sustainment pipeline. Sustainment of deployed forces includes all aspects of maintenance, base operations and support, security and force protection, and other logistics functions. Theater assets, including RCC stocks and war reserve materiel (WRM) must be maintained and effectively allocated to operations.
- **Reshape.** Once the situation is stabilized, some or all of the deployed forces may be redeployed and will then require reconstitution, including everything from replenishing stocks to dealing with accumulated backlogs in maintenance, training, and other areas. The logistics functions associated with the initial deployment are essentially repeated in reverse to execute the redeployment.

Improve Availability of Airlift Aircraft

OOTCW place a significant demand on the airlift fleet. For a variety of reasons this demand creates unacceptable operational tempo (OPTEMPO) and personnel tempo issues. Additional aircraft, while desirable, are not necessarily required to solve the problem; more efficient use of the existing fleet is the highest priority.

Inadequate aircraft reliability, particularly the C-5 reliability, is a detriment to efficient operations. High-priority C-5 sorties require several spare aircraft. The Air Force has a program underway to improve C-5 reliability, and the panel strongly supports that effort. However, the present 75 percent reliability goal should be re-examined because it appears to be based on a need to satisfy a particular MTW ton-mile goal that may no longer be relevant. Fixing the C-5 to only a 75 percent reliability level will improve the fleet capability but will not be adequate to eliminate backup aircraft scheduling requirements.

Other aircraft initiatives to pursue include continuing the C-130 Avionics Modernization Program (AMP) to achieve compatibility across the fleet; continuing the C-17 center wing tank program; and procuring the right mix of C-17 and C-130J-30 aircraft to perform the total airlift mission. KC-10s are valuable mobility assets in addition to being capable tankers. Today, the strategic airlift role of KC-10s is limited as some are chopped to U.S. Central Command to provide refueling for Navy and Marine aircraft. Acceleration of the program to equip KC-135s with pods that provide multipoint, soft-basket refueling could free up KC-10s for strategic airlift. KC-135s are poorly used and spend too long in depots. The Air Force should investigate and correct this long-standing problem. If depots are unable to perform KC-135 maintenance in a timely manner, the Air Force should consider alternative depot maintenance concepts. Also, the Commander, Air Force Material Command, should not own the largest fleet of KC-135s.

The C-130J-30 and the C-17 each have inherent capabilities to perform both theater and strategic airlift roles. Force employment planning tools should use this flexibility to provide optimal use of the fleet in moving from fort to foxhole. The methodology used to develop force structure requirements should also consider the total mobility problem rather than working strategic airlift, theater airlift, sealift, and ground transport as separate pieces.

Training sorties tie up a large number of airlift aircraft. Many of these training requirements could be completed in simulators if enough high-quality simulators were available. A coherent plan should be developed that provides the best training per dollar and considers all alternative training options.

Crew ratios are based on wartime requirements. While this should provide adequate crews for both peacetime and wartime, the active-reserve mix is not sufficient for peacetime demands. The Air Force should increase the active duty crew ratios for mobility aircraft because the high OPTEMPO for peacetime and contingency missions has become the norm.

Integrate Planning Systems

The 1997 Air Force Scientific Advisory Board (SAB) study on Air Force Expeditionary Forces aptly addressed deployment and sustainment issues. However, the integrated planning and real-time connectivity issues still need to be addressed. In fact, integrated planning should be expanded beyond the bounds of deployment and should include integration between deployment, employment, and sustainment to fully realize the vision of the EAF.

Within the logistics community, numerous stovepipes exist across the planning systems. Efforts are currently underway to solve many (but not all) of these problems. The resulting system may eventually provide integrated logistics planning, but it will not provide integration across deployment, employment, and sustainment planning systems. This is a difficult problem because of the mindset common in

developing planning systems. Generally these systems have been developed module by module with well-defined module functions. This approach needs to change. First, the overall planning architecture should be defined, then the interfaces between each of the functions should be specified. Only when this is complete, should each module be developed. The key difference is that everyone knows up front what the inputs and outputs of the modules are. This process will result in an easily integrated system.

The concept of effect-driven planning must be firmly established as the root of the integrated planning system. This concept implies that only those assets that contribute to effects-based operations should be deployed, and only in the appropriate sequence and quantity to achieve the desired effect. It also includes the need to source elements of that deployment as close (in time) to the employment site as possible. Many items are shipped by air that could go by other transportation. Today's planning and prioritization tools and organizational structures allow excessive air shipment to happen. Mobility customers should have tools available that allow proper prioritization of their cargoes.

Efforts are underway in the Air Force to provide in-transit visibility (ITV) for assets within the transportation system. These efforts should be accelerated. In addition, ITV should provide linkage into a total asset visibility (TAV) system that is expanded to encompass every item (Level 6) rather than items only at the increment level (Level 4). The objective of ACS requires these data and associated tools to provide efficient support. The logical point of data capture is at the source (deployment), but the data must be accessible throughout the system.

Today, unit type codes (UTCs) and the tools to work with them are inconsistent with the EAF philosophy. The entire UTC tends to be given the same priority and transportation mode. Also, UTCs are still structured with a Cold War mentality—that is, they include long-duration (30 to 60 days rather than the desired 3 to 7 days with reachback) support packages and large-force packages. Core UTCs should reflect the EAF philosophy with small standard pieces and easy incremental tailoring. Planning tools should facilitate and support this approach. A robust sustainment plan incorporating just-in-time resupply will give commanders confidence that they can deploy with minimum equipment and supplies.

AEFs and their associated support forces should be organized and located with respect to mobility issues. Regional consideration should be given to the makeup of the forces to minimize transit time for pickup and delivery during deployment.

Protect Forces Adequately

Significant threats to OOTCW forces exist today, and they will increase in the future. The Air Force should take appropriate measures to protect deployment and sustainment forces. The primary threats that require additional protective measures include manportable air defense system (MANPADS) missiles, blinding or dazzling lasers, and chemical and biological agents.

MANPADS solutions are being worked that can provide defense against infrared (IR) missiles. These efforts should continue with high priority. Air Mobility Command (AMC) has estimated the installation of these systems to cost $8 to $10 million per aircraft. Installation on a subset of aircraft increases fleet management problems. To reduce costs, AMC should explore the possibility of installing Group A provisions on aircraft and developing and procuring a limited number of podded defensive systems. Such pods should have missile warning and laser defensive systems. Consideration should also be given to including a retrievable towed decoy in the pod for countering radio-frequency (RF) missiles.

Detection of chemical and biological agents in time to avert adverse effects should be a high priority. Several technologies show great promise for decontamination. One technology is a nontoxic decontamination agent dispensed as a fog that has been deployed with the militaries of several nations. This agent works well for decontamination of equipment and should be explored for large aircraft decontamination. There is also a possibility that it could be used against contaminated clouds prior to the

cloud's arrival over friendly forces. Such use should be explored. Standards for decontamination should be developed jointly and be coordinated with host nations to allow rapid transition of decontaminated aircraft back into the clean fleet.

Despite some troops' concerns about the anthrax vaccine, which is presently being administered, the Air Force should continue to develop vaccines against biological agents.

Lasers capable of disorienting or blinding aircrews at a distance of several kilometers are readily available worldwide. Eye protection against multispectral lasers should be developed and fielded as early as possible.

Troops need medical care consistent with the rapid AEF. Field diagnostic tools should be developed and procured. Telemedicine capability and the associated communications should be developed. Smart ID tags should include medical histories and should be incorporated into emerging ITV systems and the Global Deployment Support System.

Improve Sustainment of All Forces

In many OOTCW, the lack of ability to sustain operations at forward locations is likely to limit mission success. Two major sustainment categories are addressed in this study. The first is sustainment of the mobility fleet and associated support equipment, which suffers from the same support shortfalls that exist throughout the Air Force. The second is the ability of the mobility fleet to sustain other operational forces.

Shortfalls in logistics support limit the effectiveness and capacity of mobility systems. C-5 reliability problems stem from spares shortfalls and obsolete and unreliable components. The Air Force should ensure that the mobility assets are properly prioritized in decisions regarding funding of spares and other reliability enhancement programs. Given the historical DoD difficulty in providing consistent support for forces, alternatives should be considered. As part of the C-5 and other reliability or life enhancement programs, the Air Force should consider contractor logistic support and guarantees for system availability.

The 1997 SAB Study on AEFs provides extensive recommendations on personnel support, force protection, waste disposal, power production, and other logistics functions. These recommendations are still relevant.

Material-handling equipment (MHE) availability is often a limiting factor for OOTCW. The Air Force has made great strides with the Tunner 60-K loader. Because Tunners are providing both transport and loading, there is potential that they may show excessive wear compared to separate transporters and stationary loaders. The additional benefits of the Tunner justify this risk if the wear is not excessive. The Air Force should establish a monitoring program to measure Tunner life. Next-Generation Small Loaders (NGSLs) should be procured to provide loading and transport capability compatible with C-130 airlift.

The Air Force has not equipped for humanitarian missions despite the frequent need to perform these missions. Several systems are repeatedly required but not available. Kosovo once again reinforced the need for an inexpensive precision airdrop capability. Rapid remote survey and autonomous landing capability at remote sites are continuing requirements that the Air Force should pursue.

Many deployed items are large and require a great deal of airlift and maintenance support. Shelters, air traffic control (ATC), power production, earth moving equipment, and petroleum, oil, and lubricants (POL) fall into this category. A balanced program to identify such items and to develop and deploy replacements should be undertaken.

Combat Search and Rescue

The Deployment and Sustainment Panel examined the combat search and rescue (CSAR) mission as part of its study effort. The CSAR mission highly leverages the aerospace power associated with OOTCW as well as conflict associated with MTW. Therefore, the CSAR mission has an important overall impact on the success of the GEO construct.

CSAR has been an emotional issue owing to conflicting mission tasking, inconsistent resourcing, and changing organizational structures. CSAR forces are neither the best-equipped or trained forces to perform the mission nor always the most available to commander-in-chiefs (CINCs). The panel strongly encourages the Air Force to make the CSAR forces the best and most available.

The panel recommends that the CSAR forces of Air Combat Command (ACC) and Air Force Special Operations Command (AFSOC) be combined. The optimum number and types of aircraft should be determined by the analysis of alternatives (AOA) study and early funding provided to solve the deficiencies in numbers and capability that is forecast by the respective commands. The specific organization that a consolidation would require is a decision for the Chairman, Joint Chiefs of Staff (CJCS), the Air Force Chief of Staff, and the Secretary of the Air Force. The warfighting CINCs would need to be coordinated with such a decision and understand its implications. Efficiencies in logistics, training, personnel, and beddown could be achieved. More important, the CINCs, EAF strike force, and a robust CSAR force with homogeneous training and capability would support complementary elements. Thus, the expectations of the aircrews sent into a conflict can be ensured.

5.2 Analysis

The U.S. Air Force has high hopes for its capabilities to project national power in the 21st century, as illustrated by the EAF construct. To realize these hopes, the Air Force must concomitantly develop its deployment and sustainment capabilities. Only if the Air Force creates the requisite deployment and sustainment capability will the EAF realize its potential.

Currently, the logistic system continues in the MTW tradition. The panel's analysis shows that many OOTCW scenarios raise logistic challenges that are not adequately addressed in preparing solely for MTW. To move forward, there must be greater airlift capacity to move the materiel needed before operations can begin. Integrated planning systems are needed that send only the right personnel and cargo at the right time. Processes and systems must be implemented that allow reliable sustainment of the deployed forces. There must be a greater ability to operate in threat environments ranging from small arms and surface-to-air missile (SAMs) to laser and chemical and biological weapons. All of these items are addressed in this deployment and sustainment report, and together they compose a logistics system that will allow the Air Force to become truly expeditionary.

5.2.1 Transition to the Expeditionary Aerospace Force

Background

The Air Force has committed to the fundamental principles of becoming an EAF and has made important strides in establishing the organizational construct. The 10 AEFs and 5 HAFs now in formation represent a critical first step toward a true EAF culture. This approach efficiently employs a constrained force structure to satisfy diverse, global taskings, and is as valid for OOTCW as it is for MTW. Indeed, since most OOTCW situations will not call for mobilization of reserve components, they may actually be more stressing on active-duty deployment and sustainment forces than combat deployments. The Deployment and Sustainment Panel is concerned that while the initial emphasis has been on implementing the operational organization, essential complementary actions involving equipment, support processes, and logistics in general have received much less attention. The EAF will not be a reality until all aspects of

this profound culture change have been completed. While this theme is a subject for the study as a whole, the Deployment and Sustainment Panel wishes to highlight some logistics topics that fall within the panel's particular charter.

In 1997, the SAB conducted a major study on AEFs.[1] While the study focused on combat operations, typically involving deployment of a mixed-fighter force, it yielded valuable data and conclusions on the general subject of expeditionary operations. In this report, we refer frequently to the '97 AEF Study while building on it to address the broader subject of deploying and sustaining expeditionary forces in OOTCW.

Logistics in EAF Training and Exercises

It is striking that in virtually every major wargame or force exercise conducted by the Air Force, the critical logistics dimension is ignored or assumed away. Cargo is picked up and delivered right on schedule, and any airlift shortfalls are miraculously covered by the CRAF. Sorties are seldom canceled for want of repair parts lest aircrew training and other important exercise outcomes suffer. Supply transactions are never delayed by lack of reachback communications or by nonavailability of priority airlift. Operational plans have no need for logistics feasibility checks because logistics is depicted as perfect. As a result, these opportunities to identify problems and experiment with fixes and work-arounds are generally lost. The fact that logistics has not been a limiting factor in mission accomplishment in recent decades contributes to this complacency.

The world has changed. The spectrum of missions and the loss of forward positioning of support resources place ever-increasing demands on a shrinking support structure. Drastic cuts in everything from airlift capacity to experienced maintenance technicians mean that logistics will not only be imperfect but may well become a significant limiting factor in future operations. The massive flow of materiel and personnel to the Persian Gulf War, which overwhelmed shortfalls and inefficiencies in logistics processes to generate high-sustained sortie rates, cannot even be approximately replicated today. The Air Force needs to include realistic mobility and sustainment planning and realistic logistics problems in exercises and training. The deficiencies that will inevitably be identified should be addressed on an equal footing with operational concerns. We do not suggest that *every* exercise needs large-scale logistics play, but we feel strongly that these elements must be included whenever real-world logistics outcomes might reasonably affect the operation being simulated.

This is doubly true in the face of OOTCW, which place different and sometimes worst-case requirements on logistics support compared to combat operations. An exercise in sustained delivery of humanitarian relief into a region with limited or destroyed infrastructure and persistent bad weather, for example, might be as important to the future Air Force as practice with a 36-fighter AEF. The Air Force should start immediately to stress integration of ACS planners into the OOTCW crisis action-planning process, including realistic logistics feasibility analysis prior to course of action (COA) selection and finalization of operational plans. As noted in the '97 AEF Study, this is essential in any AEF construct, whether combat operations or OOTCW are involved.

Training and Equipping the EAF

An important related subject concerns the way individual units are trained and equipped. For the AEF concept to be fully successful, all units with OOTCW tasking—even as a secondary mission—must be equipped for that tasking and devote appropriate training resources to it. This will be less of an issue for combat units since their OOTCW roles will be similar to their combat tasking. Training against situations such as peacekeeping in the presence of a confused situation on the ground with friendly and hostile

[1] *United States Air Force Expeditionary Forces*, Technical Report SAB-TR-97-01; Volume 1: Summary, November 1997, Volumes 2 and 3: Appendices E-I, February 1998; referred to as the '97 AEF Study.

groups intermixed will be increasingly important in the years ahead. For air mobility, transportation, security, medical, civil engineering, and other units with heavy OOTCW commitments, adequate equipment and realistic training are absolutely vital.

For most of its history, the Air Force enjoyed a substantial forward-basing structure, prepositioned materiel, and a large force that allowed large formations to be dedicated to primary theaters. As it transitions to a much smaller, largely U.S.-based force with limited overseas infrastructure, traditional mindsets and procedures must change. This is the fundamental motivation for an EAF. However, we do not yet see the expeditionary concept being implemented in key areas such as shared ownership and use of equipment, design of logistics processes for deployed operations, and effective use of information systems to cope with the challenges of the new operational and support environment.

A completely flexible EAF, able to go anywhere in any numbers to accomplish any mission on short notice, would require a level of support equipment, RSPs, and other deployment materiel that would be prohibitively expensive. Instead, by changing old mindsets about ownership and use of such assets, the Air Force could achieve a higher effective level of support without buying much additional inventory. A classic example involves heavy equipment such as vehicles and flight line aerospace ground equipment (AGE). Every squadron owns its units, is accountable for them, and plans to take them on deployment and bring them home when the squadron redeploys. If, instead, the Air Force used the Marine Corps model, under which an arriving unit uses the equipment left behind by its predecessor and becomes accountable for it, a huge amount of wasteful cargo-hauling could be eliminated. A related idea would be to establish theater equipment sets. In situations in which deploying units rotate in and out under a long-term operation, a similar reduction in strategic airlift requirements could then be achieved. In general, the idea is to consider new paradigms for providing the means to conduct operations even, or perhaps especially, when these run counter to established culture.

Such equipment sharing would be greatly facilitated by improved discipline in the ways units are equipped and in the support packages they use when deployed. While flexibility to tailor these packages to particular missions and operating conditions is essential, the current situation in which every wing has a different idea about what to take and acts accordingly, should give way to more standardized and predictable tables of organization and equipment. Similarly, common planning tools and databases, common deployment doctrine and practices, and extensive exercises in multi-unit combined forces would pave the way for an expeditionary force that seeks to minimize the amount of cargo that must be moved in any mission scenario.

Information Support to EAF

The EAF has the ability to rapidly deploy and employ forces globally from the United States and from a limited set of overseas bases. This translates into greatly improved information processes enabled by real-time connectivity among the elements of a deploying force and the command and control (C^2) structure. For example, a deploying force should have ITV of deploying personnel and cargo, deploying flight crews should have access to mission-planning data and threat updates, and support personnel should receive the latest information on conditions at destination airfields. Once the force is in place and executing the mission, ITV must progress to TAV, which enables efficient sustainment and mission success. The need for information support is as great, and perhaps greater in some respects, for an OOTCW force going into a large-scale disaster or impending civil war than for a combat force about to encounter a well-understood opponent.

Coordination of Humanitarian Relief Operations Airlift

Humanitarian Relief Operations (HUMROs) illustrate the kinds of special problems with deployment and sustainment that arise in OOTCW. For example, one of the greatest challenges is receiving the tremendous number of aircraft that arrive with supplies unannounced.

During Operation SUPPORT HOPE in Rwanda, the ramp space available to large aircraft was extremely limited; it was essential that aircraft unload quickly to make room for others waiting to land. The problem was exacerbated in two ways. First, unannounced aircraft, usually from private relief organizations, were arriving continuously. Sequencing them became a large problem and was unsafe—any given aircraft was at risk of being unable to land. Second, unloading these aircraft usually took inordinate amounts of time because they were not loaded using modern methods. Huge AN-124 aircraft, for example, were hand-stacked with cargo, requiring them to be unloaded by hand as well, a process that could take eight hours on an airfield with room for only two large aircraft. Moreover, too much time was spent unloading items for which there was a local surplus, and marshalling areas were overflowing, while more critical supplies could not get into the airfield.

Figure 5-2. *A Huge Cargo Aircraft Arrives Unannounced in Africa, Taking up to 8 Hours to Unload by Hand*[2]

Similar problems were encountered during the HUMRO for Hurricane Mitch. Local infrastructure was overwhelmed by the scope of the disaster, and relief organizations worldwide descended on the region. It was very difficult to move material to the places it was needed most because of the clogged airlift structure.

It is necessary to provide better coordination of all airlift traveling to disaster zones. The means to provide this coordination raise considerable challenges. The international environment does not possess the structure of a civilian international on-scene command (such as a civilian CINC). The civilian airlifts which represent the vast majority of unannounced airlifts have little incentive to submit to military organizations. Therefore, the temporary solution may lie somewhere in between: civilian representatives from the United Nations working side by side with CINCs to communicate with civilian relief organizations to coordinate flows.

While the overall issue of transitioning fully to the EAF is a matter of the greatest urgency for the Air Force, the panel is concerned that the mobility and sustainment dimensions receive the same emphasis as the operational dimension. The ’97 AEF Study produced results in the deployment and sustainment areas that are still valid and have only begun to be acted upon. The Air Force can generate significantly greater capability across the mission spectrum with little or no additional investment if traditional ways of doing business give way to an integrated process of planning, provisioning, preparing, and executing missions.

[2] Joint Forces Air Component Commander/Director of Mobility Forces briefing.

Logistics Dimensions of Global Engagement Operations

The panel urges the Air Force to explicitly acknowledge the deployment and sustainment functions that are inherent in each element of each phase of the GEO construct. This chapter discusses the linkage between GEO and the master processes of ACS. Only when the operational side of the global engagement vision is completely matched by the associated support processes and resources can GEO become an effective basis for applying aerospace power. This in turn demands that every step—from formulating doctrine to conducting training and evaluating unit readiness—explicitly account for the logistics processes that enable each operational mission, whether in war or in peace.

From the logistician's perspective, the GEO phases of the Shape-Respond-Reshape map logically onto the processes in the various functional areas of ACS. Figure 5-3, taken from the latest draft of the U.S. Air Force ACS concept of operations (CONOPS),[3] emphasizes the role of ACS in achieving force closure in the early stages of an operation and then sustaining the force to completion. The ACS CONOPS is the basis for a doctrine document now in preparation. Figure 5-4 shows how the various elements of each GEO phase are related to the seven "master processes" of ACS. These master processes provide the framework within which transporters, suppliers, maintainers, communicators, force protectors, and others in the support force can plan, train for, and execute their roles in an operation.

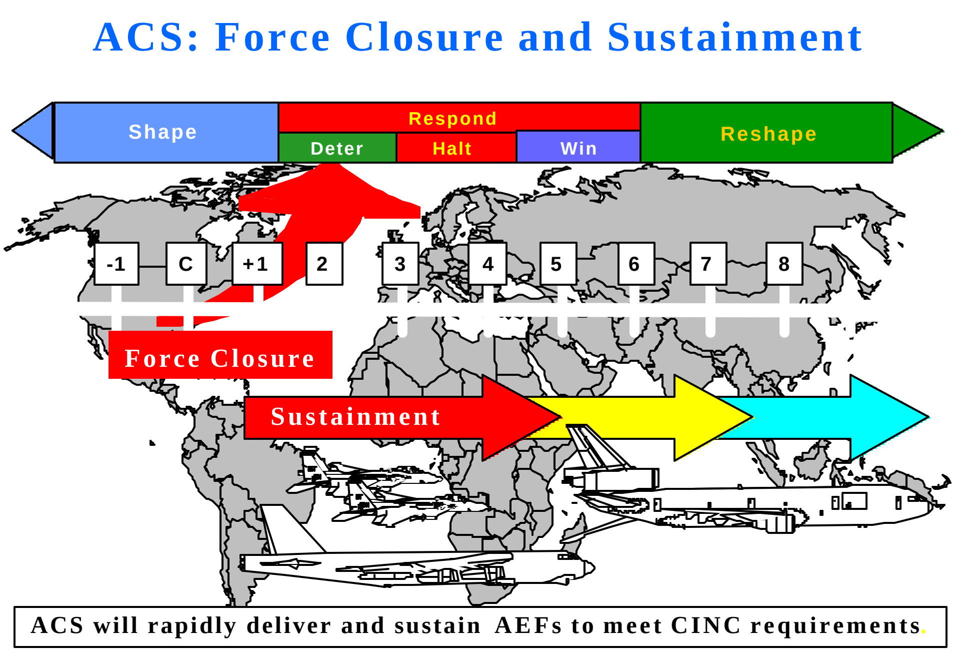

Figure 5-3. *Structured Agile Combat Support Processes Are Critical to Closing and Sustaining the Force in Any Operation*

Some of the more important deployment and sustainment aspects of the GEO phases are as follows:

- **Shape Phase**
  - Maintain the RSPs, AGE inventory, aircraft-phase inspection status, and other elements of logistics readiness for primary deployment units at full readiness

[3] United States Air Force Agile Combat Support Concept of Operations, Draft, 1 May 1999.

– Continuously update deployment databases
– Posture the tanker and airlift force according to current operational situations; for example, for a threatened crisis, preposition tanker task forces for rapid establishment of an air bridge
– Maintain the infrastructure and stock levels for theater support assets, including RCCs, WRM, and theater airlift
– As part of deliberate planning, establish deployment and sustainment requirements for MTW and OOTCW
– Realistically exercise all relevant operational, deployment, and sustainment aspects of expeditionary operations

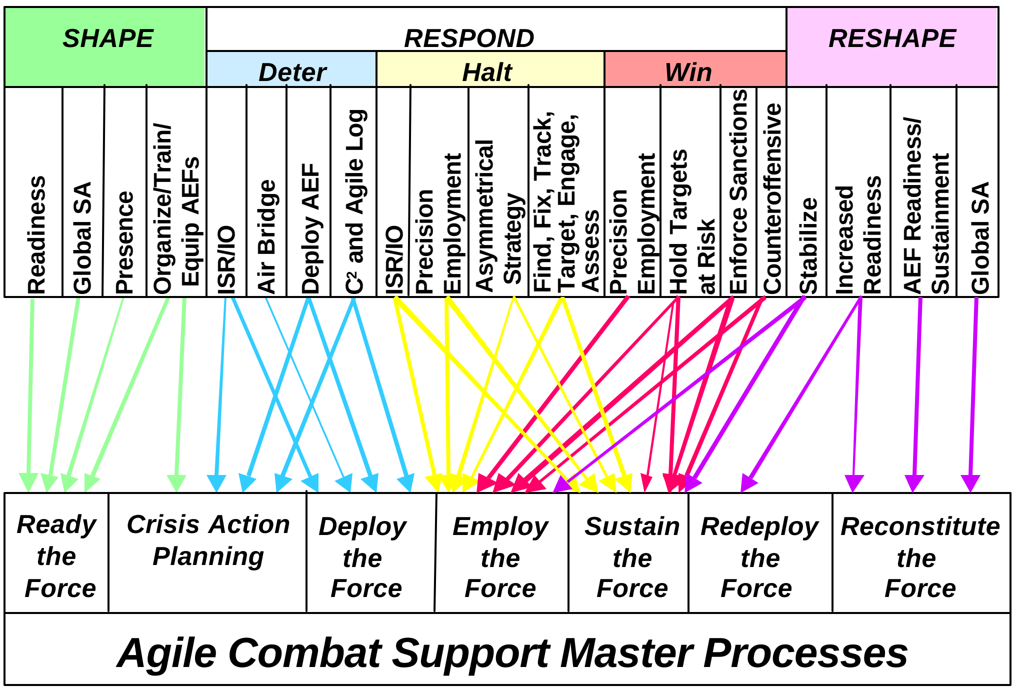

Figure 5-4. *The Phases of Global Engagement Operations Map Onto the Master Processes of Agile Combat Support*

- **Respond Phase**
  – Deter
    * Update deployment and ITV data systems with specific information on the theater and forward-operating locations
    * Conduct integrated crisis action planning with full involvement of ACS planners and with logistics feasibility analyses at appropriate points
    * Tailor deploying forces and support packages and source them from appropriate units; minimize deployed footprint
    * Establish the air bridge and in-theater airheads
    * Apply ITV and TAV to efficiently manage deployment and sustainment

    * Employ reachback, time-definite delivery, timely retrograde of personnel and materiel, and other elements of ACS

    * Establish incremental sustainment through appropriate combinations of pipeline flow and stockpiles

  – Halt/Win

    * Provide required sustainment functions, including maintenance and munitions, personnel support, base operations, and security and force protection

    * Maintain incremental sustainment

    * Maintain and employ theater infrastructure, including RCCs

    * Employ dynamic replanning of sustainment

- **Reshape Phase**
  – Apply the same mobility functions as in the Shape phase during redeployment of forces
  – Reshape and modernize readiness stocks to prepare for current taskings
  – Correct backlogs in training, equipment maintenance, etc.

As the above tabulation suggests, every aspect of GEO must be underpinned by robust, mature, and properly resourced ACS functions. Allowing for differences in detail, the list applies as much to a HUMRO as to an MTW deployment. In the remainder of this chapter, we discuss specific topics in this area that are especially important for OOTCW.

5.2.2 Increase Mobility Capability for OOTCW

With increasing frequency, the Air Force must respond to national security taskings during OOTCW. During OOTCW, mobility requirements often exceed capability. To correct this imbalance, the Air Force should reevaluate its method for determining the mobility force structure.

Currently, mobility forces are notionally sized on the requirement to support two nearly-simultaneous MTWs with attendant moderate to high risk. Risk is inherent in this force structure because these forces are constrained by budget realities to a smaller number than operational analysis has shown is required. In addition, the MTW scenario yields more mobility capability than is available for OOTCW because it is based on mobilizing the ARCs, activating the CRAF, and a structured and robust en route support system.

However, the most stressing requirements will occur during peacetime or OOTCW. The problem often manifests itself as a shortage of aircraft or crews. Several factors contribute to this problem. First, there is no basis for establishing peacetime mobility force requirements, unlike wartime, when requirements are described by the CINC and contained in the CINC's war plans. Therefore, it has always been assumed that any capability that could meet war plan requirements could also meet any OOTCW requirements. However, on numerous occasions since the end of the Cold War, this assumption has proven to be invalid because the force structure available is different during OOTCW from what is available during a MTW.

During OOTCW, mobility taskings such as regularly scheduled channel missions, resupply missions, training missions, and other normal peacetime requirements remain. When contingency requirements are added, the limited number of aircraft and crews meet a smaller percentage of the total requirements. Complicating this problem during OOTCW is the restriction that, until its mobilization, the ARC can be tasked only on a volunteer basis. In addition, the CRAF is not normally activated and civilian airlift is

acquired on an "as available" basis. As a result, peacetime and contingency requirements often exceed the capability of available forces.

Other factors affect the airlift shortfall. The near-term problem is exacerbated by the rapid drawdown of the C-141s. The limited range of the C-17, the reliability of the C-5 and older C-130s, and the lack of standardization among all C-130s are hardware limitations that contribute to the shortfall. Other issues that affect the shortfall include the active-ARC mix, the inefficient use of mobility aircraft by the CINCs, excessive depot time for KC-135s, antiquated simulators, and a transportation rate structure that establishes incentives for efficient use of airlift. These factors restrict the availability of airlift aircraft and crews and cause nonsupport of legitimate requirements and an unwarranted high OPTEMPO in the mobility force. The high OPTEMPO and resulting turbulence is a major contributor to the retention problems that the Air Force now faces.

The mobility force structure requirements are currently determined using an arbitrary goal for supplying the forces needed to fight two nearly simultaneous MTWs. In fact, "determined" may be too strong a word; "validated" may be more appropriate because the force structure appears to be predetermined and then checked using a suite of analytical models. In any case, the only scenario receiving any significant effort is the two major regional conflict (MRC) scenario. Both the size and manning of the force structure result from this approach, and they do not properly account for the very real peacetime and contingency uses of these forces. The Air Force should change its process for determining mobility force structure. Both OOTCW and MTW requirements should be calculated, and the size and shape determined according to the more stringent of the two requirements.

Currently, the C-5 reliability improvement program goal is set at 75 percent. This number was determined by considering the planned C-17 buy, the planned C-141 retirements, and the reliability necessary to meet an arbitrary ton-mile goal for a two MRC scenario that is likely to be revised this year. The Air Force should modernize the C-5 to improve its reliability in a more rational manner. Increasing reliability to a higher percentage would have significantly reduced fleet turbulence and improved aircrew utilization. Reportedly, Lockheed-Martin offered an 81 percent reliability improvement. Boeing argues that procuring more C-17s and making reliability improvements only on the C-5Bs is the most cost-effective approach. All such options should be evaluated using cost-benefit analysis. The Air Force should determine the optimal cost-effective reliability for the entire airlift fleet and adjust budgets and force structure accordingly. Options considered should include procurement of the optimal number of C-130J-30s to take advantage of their inherent strategic airlift capability and improved reliability and maintainability. The C-130J-30s and C-17s possess both strategic and tactical mission capabilities. These inter-theater and intra-theater capabilities enable both aircraft to be used in a variety of missions including hub-and-spoke and direct-delivery operations. Force structure requirements should take into account all the capabilities of these new airplanes.

The relatively short range of the C-17 also impacts the flexibility of the airlift fleet by requiring either tankers or C-5s for many missions. The Air Force should install center wing tanks fleet-wide to improve the C-17 range. A stretched version of the C-17 as a cost-effective option for strategic airlift should also be investigated.

More than 30 versions of the C-130 are in inventory and there are seven different pilot qualifications for these airplanes. The multiconfiguration of the current fleet does not allow an intermix of flight crews, maintenance crews, parts, and supply. This limits the efficient use of aircraft and personnel and increases the support tail required. The Air Force should standardize the C-130 fleet by continuing the C-130 Avionics Modernization Program to improve reliability and maintainability and allow commonality between aircraft.

The Air Force should reexamine the active and ARC aircraft and aircrew mix in light of the OOTCW tasking. Prior to mobilization, ARC aircraft and aircrew are available only on a volunteer basis. As a result, their capability to mobilize is restricted and may not meet OOTCW requirements. A recent example is the need to activate mobility forces for Kosovo. Since mobilization is a politically influenced decision, it is often not timely enough to meet OOTCW requirements. It is likely that taking into account OOTCW tasking would lead to increasing the active-duty crew ratio or adjusting the active and ARC mix upward for mobility aircraft.

Navy and Marine refueling requirements have led to KC-10s being based in theater for extended periods. Their training does not prepare the Navy or Marines to effectively use the current KC-135 refueling hose and basket. Accelerating the KC-135 multipoint, soft-basket refueling capability will allow theater commanders to free up KC-10s for the airlift role.

KC-135s spend an excessive amount of time in depot maintenance, which decreases the availability of this critical resource. If depot maintenance efficiency cannot be quickly improved, the Air Force should consider alternative commercial practices or contractor depot maintenance with guaranteed aircraft availability.

Several training tasks that are being done in actual aircraft could be done more efficiently and less expensively in simulators. The Air Force should upgrade flight simulators to improve quality of training and decrease proficiency training time required on the aircraft. For example, the C-5 simulator cannot be used for air-refueling training because of poor replication of air-refueling flight conditions.

Where applicable, require replacement units to make use of the previous unit's equipment. Currently, most units bring their own RSP, AGE, vehicles, and other support equipment. Departing units retrograde this same equipment. Requiring units to transfer assets will significantly decrease the airlift requirements. Other Services such as the Army and Marine Corps have already adopted this practice, so there is no reason the Air Force cannot do the same.

The Transportation Working Capital Fund (TWCF) was established to fairly charge customers for the use of airlift. Unfortunately, TWCF rates are set in neither a timely nor a rational manner. For example, customers may find it less expensive to use a C-5 than a C-130 for a trip that either airplane could accomplish. The Air Force should recommend a rate structure for the TWCF that establishes incentives for the efficient use of airlift. The customer should be financially rewarded for early definition of requirements and indifference to type of aircraft.

5.2.3 Integrated Planning and Execution

The Need for Integrated Planning and Execution Capability

The Air Force vision of GEO was developed as the result of the *Joint Vision 2010* (*JV2010*) strategy to provide full-spectrum dominance in any environment requiring the use of military forces. *JV2010* encompasses the entire spectrum of Air Force operations, including HUMROs, noncombatant evacuation operations (NEOs), natural disaster response, small-scale contingency operations, and MTW.

The Air Force implementation of GEO is accomplished through reorganization and implementation of the EAF. The core capability of the EAF is represented by its primary deployable force element, the AEF, which consists of two or more Air Expeditionary Wings (AEWs). The Air Force has aligned its forces to provide 10 AEFs, used for rotational support of steady-state deployment operations and "pop-up" contingencies.

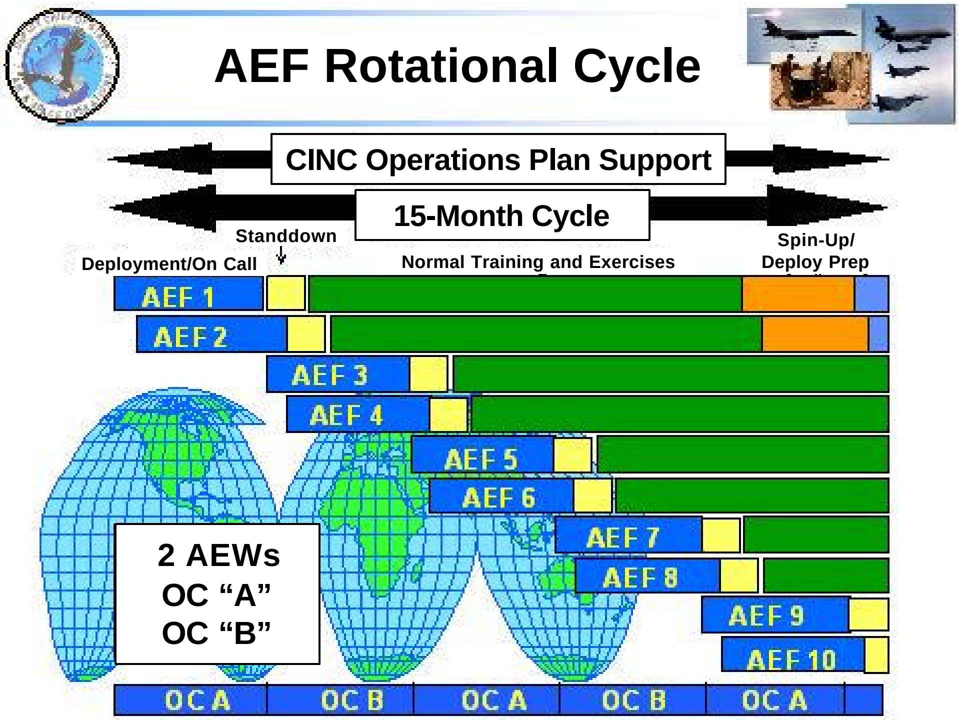

Figure 5-5. *AEF Coverage for Global Engagement Operations*[4]

The realignment of the Air Force into 10 discrete AEFs presents the forces in a consistent, capable manner, and also stabilizes the forces and limits the impact of rotational taskings on recurring training and certification requirements.

This effort to stabilize the force is essential for the future of the Air Force; however, the current planning cycle for steady state operations is lengthy, as shown in Figure 5-6.

4 AF/XOPE.

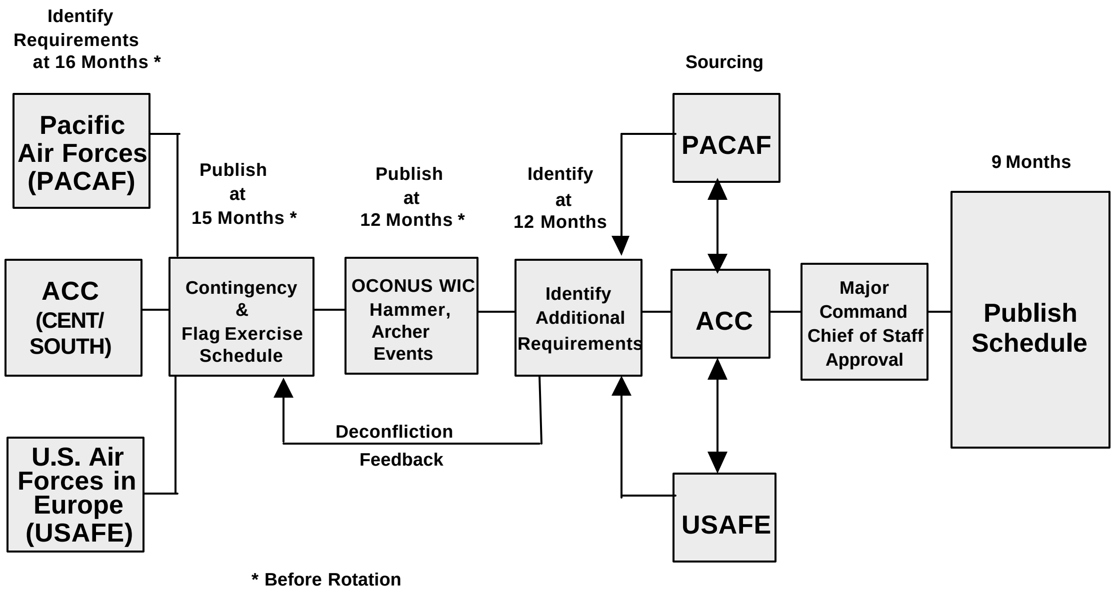

Figure 5-6. *AEF Rotational Planning Cycle for Steady-State Operations*[5]

In order to meet the time-sensitive requirements of the more-demanding but less-predictable "pop-up" scenario, the Air Force must develop the capability to deploy and employ an AEF anywhere in the world within 72 hours. The '97 AEF Study analyzed the constraints on AEF deployment in detail. Current planning systems are not designed for this demanding, time-constrained effort.

We must plan faster than we do now. We need tools to support rapid AEF employment with a reduced deployment footprint. Current planning processes do not adequately support employment of the EAF's primary force element, and the AEF.

The notional timeline for AEF employment assumes 24 hours of strategic warning. Best-case estimates allow anywhere from 4 to 24 hours to accurately formulate the composition of the AEF (including combat elements, combat support, and combat service support elements), gather information regarding the operational environment (beddown locations, en route stations, threats, and available sources of support), source and tailor the AEF accordingly, and position initial elements of the air bridge.

[5] HQ ACC.

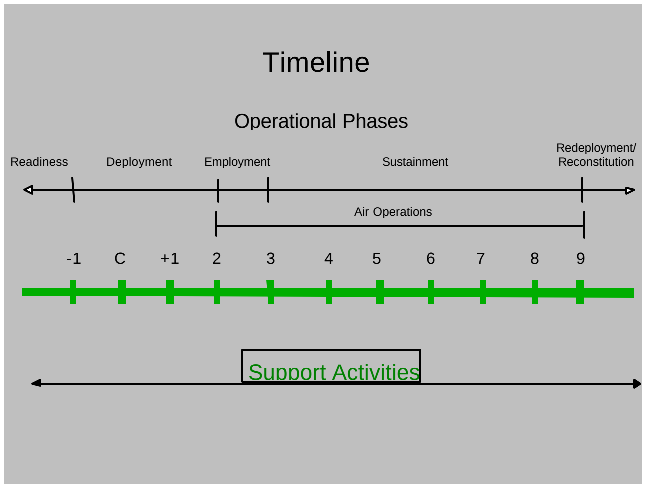

Figure 5-7. *AEF Employment Timeline—Capability Within 48 Hours of Deployment Order*[6]

The deliberate and crisis-action planning model used to support Air Force operations is embodied in the Joint Operational Planning and Execution System (JOPES). JOPES prescribes both the processes and the automated data processing tools used to identify requirements, source mission-capable (MC) resources, and to plan, execute, and monitor movement of those resources into a theater of operations. Although marginally adequate to these tasks in a deliberate planning scenario, JOPES is not responsive or timely enough to perform them within the timeline of no-notice AEF employment; nor does it integrate with employment or sustainment planning systems.

6 AF/IL AEF Analysis, January 1998.

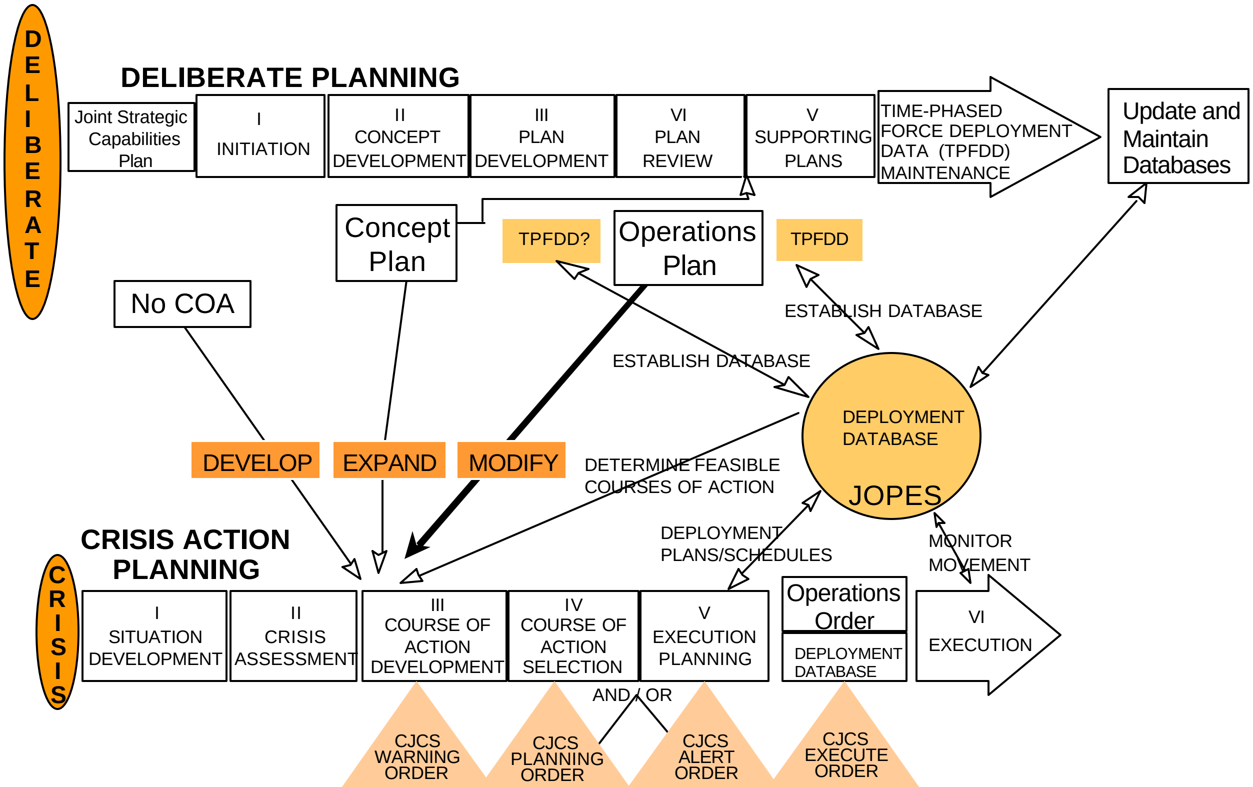

Figure 5-8. The Joint Operational Planning and Execution System[7]

The planning tasks described above must be considered together with the roles and responsibilities of the Unified Combatant Command and its supporting components in order to frame the context in which these recommendations are made. It is the division and synchronization of responsibilities among these participants, as well as the constrained timeline for AEF definition and deployment, that underscores the need for an integrated and highly automated approach to planning and execution.

Operational and Systems Architecture

History is full of examples of failed planning systems, which tend to be overly ambitious. The three steps to achieving a workable planning system that avoids the stovepipes of present systems are

1. Develop an overall architecture (operational architecture)
2. Establish and control the interfaces (systems architecture)
3. Build the modules

The Air Force has always started at step 3 and never bothered to work back to ensure that the operational architecture requirements were fully met. This has resulted in a wide variety of hardware systems and incompatible functional applications that cannot pass or accept data easily.

The Air Force should develop an operational and systems architecture for the integrated planning and execution system that incorporates descriptions of the functionality required and the interfaces between each process represented in the architecture.

[7] U.S. Transportation Command J34, February 1999.

The Operational Architecture does not deal with the design of computer systems or selection of hardware and software. Rather, it focuses on the core processes essential to providing the right information to users at the right time in each process, as shown in Figure 5-9.

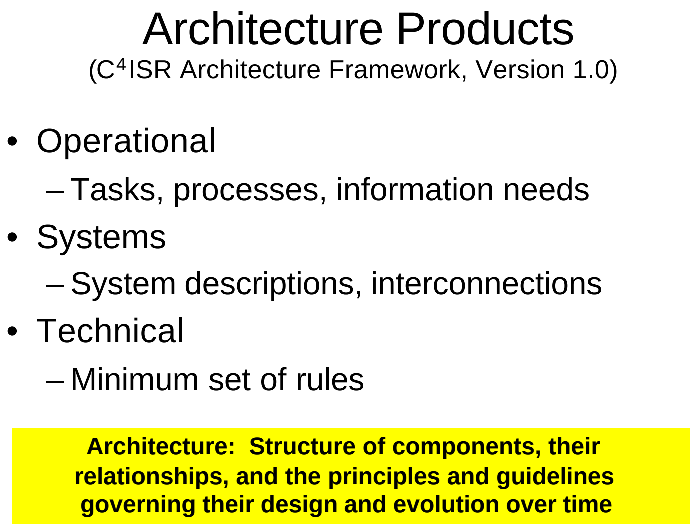

Figure 5-9. *Types of Architectures*[8]

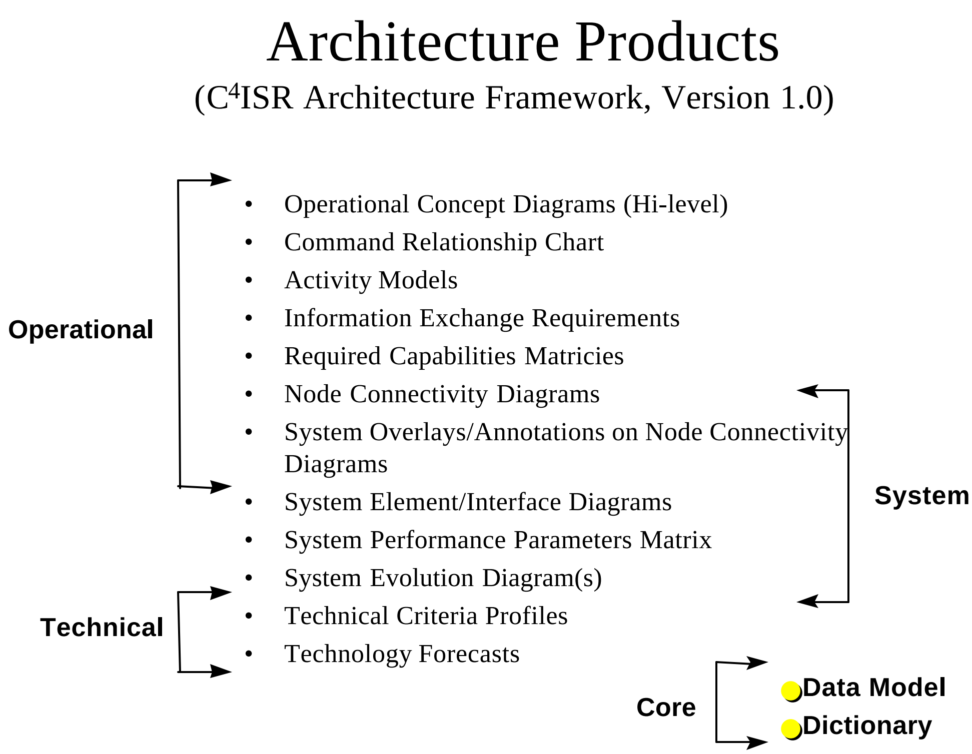

Figure 5-10. *Suggested Elements for Inclusion in Operational and Systems Architectures*[9]

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[8] Deputy Chief of Staff, Communications and Information (AF/SC).

Planning for deployment and sustainment of AEFs must be integrated with the concept of operational employment at the earliest opportunity. Ideally, integration should occur during development of optional COAs—a task performed by the gaining theater CINCs and in coordination with their components.

Automated Force Selection

The Air Force should develop a planning system that provides an automated (expert knowledge–based) selection of aerospace systems, optimized to achieve the required effect, for validation by the CINCs.

To facilitate integration in the COA selection process, the Air Force should make available an automated, semi-intelligent decision support tool that suggests appropriate force packages based on the operational environment and the intended employment effect. The Joint Forces Air Component Commander (JFACC) Planning Tool (JPT), available as an add-on in the current fielded version of the Contingency Theater Automated Planning System and included in the impending release of the Theater Battle Management Core System version 1.0, meets some of these criteria. The strategy-to-task decomposition incorporated in this tool suggests centers of gravity and resulting target sets that are likely to have a desired effect on an opposing nation. The functionality could also be expanded to accommodate a prioritized election of assets to support nonhostile aerospace engagements, using the same strategy-to-task construct.

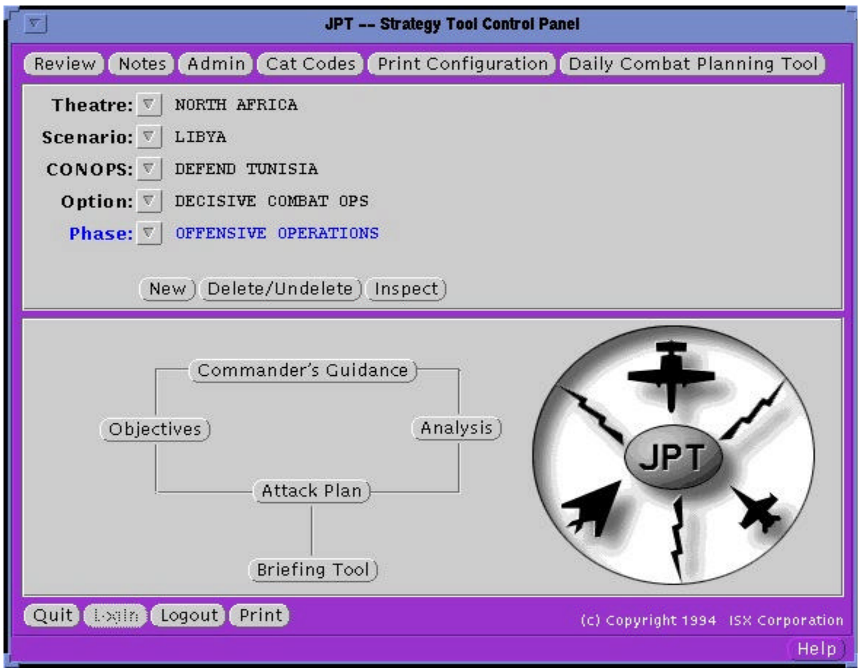

Figure 5-11. *The JFACC Planning Tool—Strategy to Task in Action*[10]

This tool demonstrates the type of functionality required and could be extrapolated to include a knowledge-based integration of munitions performance characteristics and rudimentary weaponeering. These elements and the desired OPTEMPO established in the phases of the CINC's operations order suggest the appropriate force packages that should be deployed. (Although this capability is not currently a part of the JPT, it should be developed.)

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[9] AF/SC.

[10] ISX Corp.

The Air Force should develop an automated force beddown tool based on the operational and employment characteristics of selected forces.

The resulting notional force requirements can be used as the primary input for an automated force beddown capability similar to that incorporated in the prototype Joint Logistics Planner (JLP). The JLP consists of several component elements intended to complement the JPT, one of which automates the process of force beddown. The Air Base Assessment Module uses the operating characteristics of the selected forces to optimize beddown at available airfields while considering key logistics factors, such as fuel storage capacity and runway length. The full suite of prototyped JLP modules includes additional assessments for munitions storage and fuel delivery. These modules, together with the JPT, could be better integrated and fielded on a standardized platform connected to the Secret Internet Protocol Router Network to provide the basis for a fully integrated planning system.

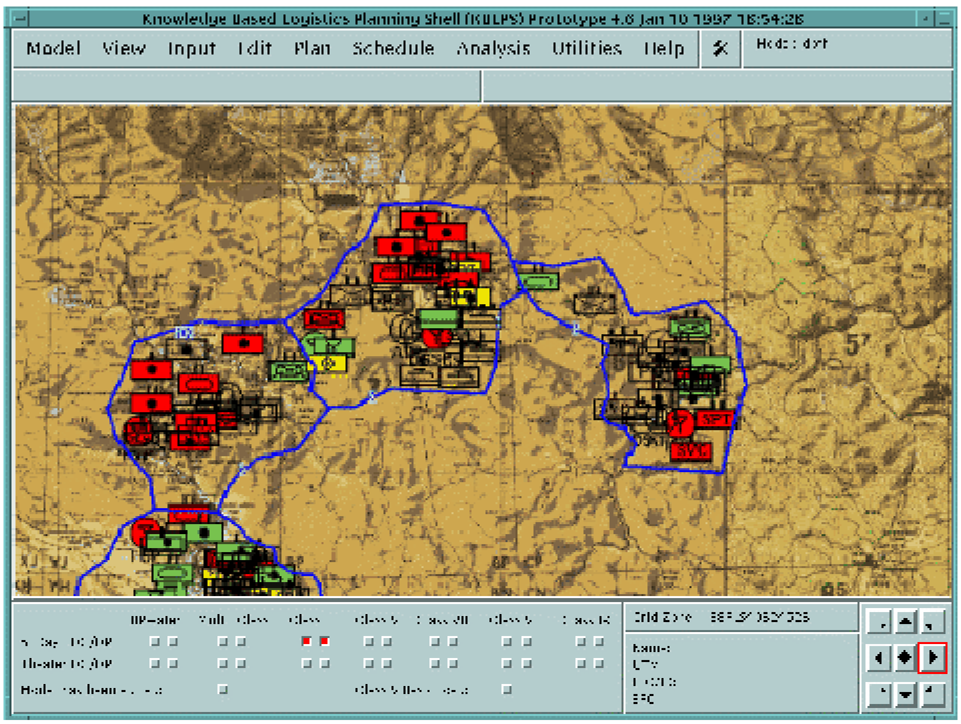

Figure 5-12. *Air Base Assessment Model—Optimizing Force Beddown*[11]

The output of these two decision support tools must be validated by the CINC's air component staff element responsible for air campaign planning, the Air Operations Center, or the deployed Aerospace Expeditionary Task Force.

Once validated, sources of support for the deploying force can be identified and evaluated to ensure a prioritized sequence of mission-essential capability.

Existing planning tools do not support real-time development of accurately tailored UTCs. This results in misallocation of scarce transportation resources based on inaccurate movement requirements, since nonessential cargo is automatically moved with essential elements of UTCs.

[11] Synergy, Inc.

Visibility of Support Sources

The Air Force should develop worldwide, near–real time visibility of available sources of support, including forward-deployed forces, other Services, host nation support, and contract sources to reduce the deployment requirement.

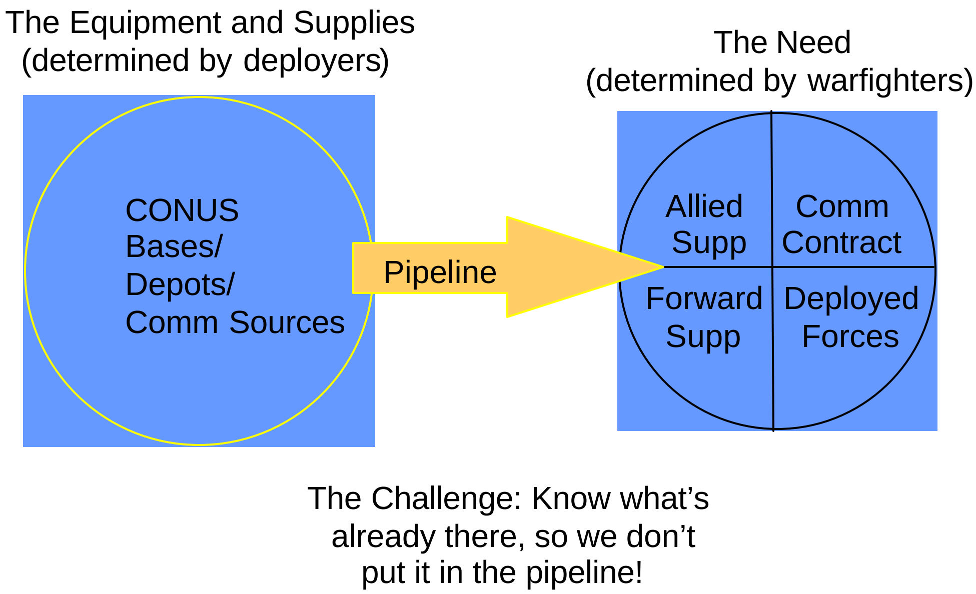

Figure 5-13. *Asset Visibility—The Key to Footprint Reduction*[12]

Visibility of assets includes more than simply a database of stock numbers; it implies the ability to assess the condition of the asset, the allocation of the asset (commitments to other units and excess capacity for shared use), and formal commitments documented by commercial contract or international, interagency, or intracommand agreements. It should include not only those items available in the regional supply system of the military Services but also those items available from local vendors close to the area of intended use.

In general terms, sourcing of support should focus on the earliest delivery date and time to meet the requirement for use; usually, that will mean the closest physical proximity. However, rapid delivery channels (either commercial or military) may provide the quickest response time; therefore, the transportation links to the employment site should be of prime concern in both the beddown selection phase and the sourcing of sustainment.

This capability has been prototyped and is being fielded by the Deputy Chief of Staff, Installations and Logistics (AF/IL) as the result of an Air Force Research Laboratory (AFRL) research and development (R&D) project known as the Logistician's Capability Assessment Toolkit (LOGCAT) suite. The Survey Tool for Employment Planning incorporates a database of facilities available at fixed, preplanned operating locations, and has the ability to allow rapid updates from field-deployed Advance-on-Ground survey teams. However, it does not incorporate the comprehensive perspective of host nation support, commercial source availability, or lateral service support. The panel recommends continued development of this capability to incorporate these aspects to reduce the deployment footprint even further.

[12] AF/ILXS.

Automated Tailoring of Force Packages

The Air Force should develop tools to automate UTC tailoring according to available resources in the employment area and their allocation to deploying units.

Once all available support assets near the employment area have been sourced to reduce the transportation requirement, the residual requirement may be sourced by the force provider (normally, another CINC, such as U.S. Atlantic Command[13]). Where possible, optimizing transportation should also be a factor, choosing units located in the same geographic area and using alternative transport modes to reduce in-transit times.

Since tailoring of UTCs requires a commitment to provide support for the tailored capabilities, it is essential that the commitment of available support assets be fully documented and enforced by the gaining command.

The Air Force should continue to develop service "feeder" systems (such as the Air Force Deliberate and Contingency Planning and Execution System [DCAPES] and its designed integral elements) that accurately capture UTC data at their input source for movement planning. These systems should provide those data directly to JOPES, enabling worldwide visibility.

Another prototype component of the LOGCAT suite, UTC-Dynamic Tailoring, provides an interactive, collaborative capability for planners from supported and supporting commands to reduce deploying assets. To be fully functional, however, this prototype must be further developed and funded for fielding to all commands and wings; the implementation of this tool, as with all others, must be done in the context of the operational architecture mentioned earlier.

Only a dynamic, interactive system will permit rapid tailoring in sufficient time to transmit the reduced movement requirement to deploying units. This tailoring capability must therefore be a fully automated function of the integrated planning and execution system, supported by robust and rapid communications pipelines capable of supporting logistics C^2 requirements.

The ongoing SAB study on implementation of the Battlespace InfoSphere should be reviewed for insight in development of the requirements for logistics C^2.

[13] Now called U.S. Joint Forces Command (USJFCOM).

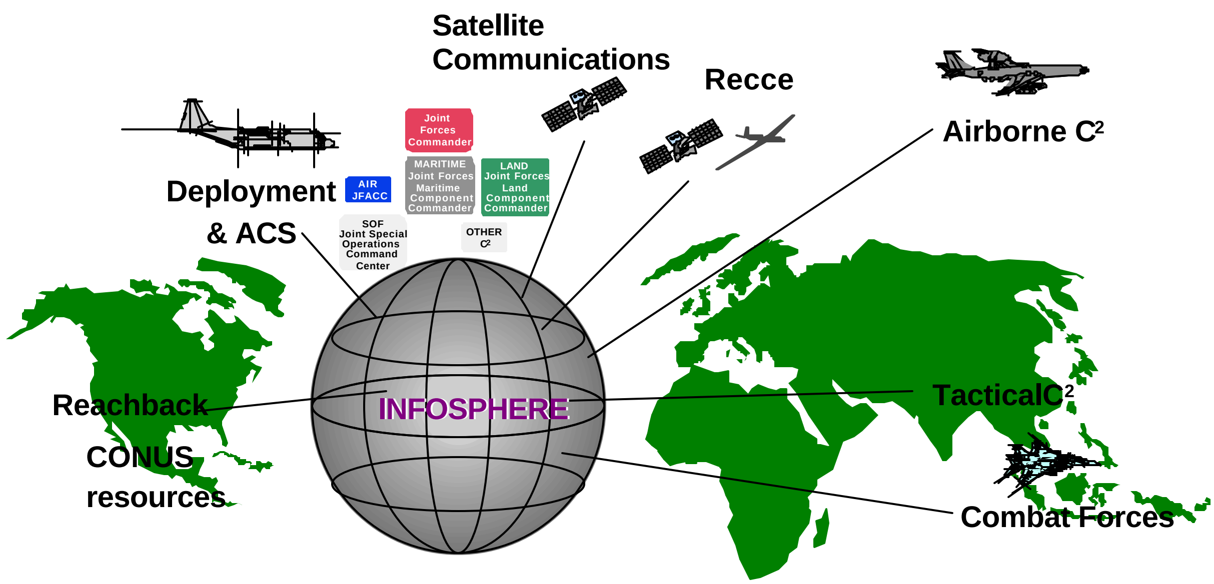

Figure 5-14. *The Battlespace InfoSphere*[14]

Optimize Deployment Flow

The Air Force should optimize deployment flow to achieve early effects-based employment capability. Even more critical than accurate tailoring is the proper prioritization and sequencing of cargo to enable the rapid generation of a credible capability at the employment location at the appropriate time. In some situations, this will mean the incremental development of support capability with priority given to combat assets; in others, appropriate prioritization will require early deployment of support forces, with combat assets arriving only after a real capability to generate sorties has been established.

Current UTC structure is not flexible enough to sequence pieces of UTCs to rapidly build the appropriate capability (including transportation throughput) in the area of responsibility.

The Air Force should develop a set of core EAF UTCs or force packages for typical force requirements (that is, a six-ship fighter slice with associated maintenance, munitions, or HUMRO package with base operating support) and greatly improve our ability to tailor and integrate these UTCs. This capability should be built with an expert rule base capable of selecting and integrating individual deployment echelons and increments from several UTCs. This optimized deployment flow would adhere to the most basic tenet of logistics: the right stuff, at the right place, at the right time.

Current ITV systems will not fully meet users' needs for cargo information. Information available in current systems is limited to Level 4 (increment level summary); to be of functional use to the warfighter for theater ACS, visibility of Level 6 (national stock number level detail) is essential.

Develop Better In-Transit Visibility

The Air Force should apply the model used in the development of the Air Force integrated deployment system (IDS) to the process used for cargo movement.

Specifically, individual work centers need to be provided with a tool to link the detailed cargo increment inventories available in DCAPES to an increment-level identification tag (our technical preference is two

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[14] AF/SC.

dimensional (2-D) barcodes, which are both inexpensive and data-rich). Work centers could produce the barcode label and attach this label to the increment placard or pallet identification tag. In addition, connectivity and interoperability with other functional support systems (for example, Cargo Movement Operations System/Transportation Coordinator's Automated Information for Movements System II, Computer Aided Load Manifesting/Advanced Automated Load Planner, and Joint Total Asset Visibility) is essential to ensure that this information is fed to centralized planning systems and available to all users.

The panel recommends the investigation into and expanded use of handheld data-collection devices (palm-size computers with barcode scanners built-in or attached) as the primary means for recording arrival and movement of cargo increments. These inexpensive devices are designed to synchronize with standard desktop computers via connection by a serial port cable, a standard or wireless telephone modem, or a local area network (LAN). They can update a central tracking database within seconds, making increment movement available to data systems in near–real time. Additionally, other planning systems will be capable of leveraging the small investment in these devices to provide expanded flexibility for use in deployment and employment.

Another technology initiative worthy of further investigation is the "Weigh in Motion" system developed by Oak Ridge National Laboratory, currently under study by the AMBL. This system uses in-ground weight sensors combined with laser profile measurements to automate collection of dimension and weight data. The technology can be retrofitted to existing in-ground scales and configured to record data automatically.

Dynamic Replanning

As assets begin to arrive at the employment site, they are committed to generating sorties. Some assets will be consumed, creating a requirement for replacement assets such as spare parts. Additional information that is developed as a result of new intelligence data or pilot reports of bomb damage assessment against target sets may change operational priorities, resulting in the need for different types of munitions or other resources. The rapid unanticipated changes in the operational environment require the ability to adjust the flow of resources to the employment location with equal flexibility.

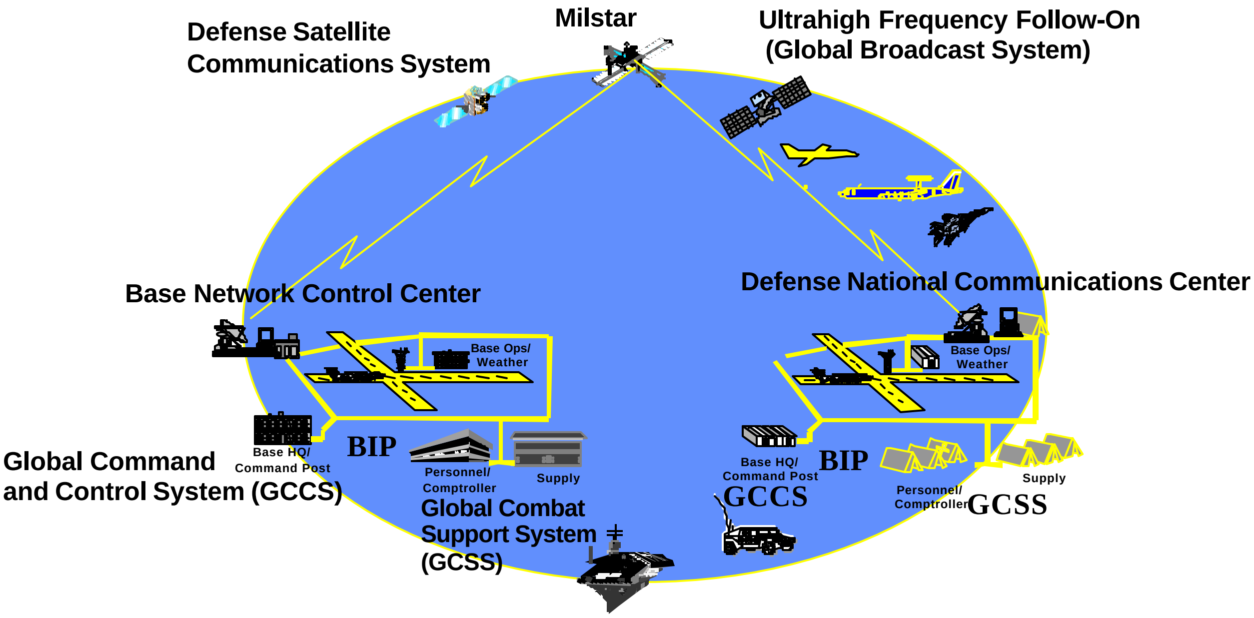

Figure 5-15. *Continuous replanning should be used to reevaluate ACS requirements on a dynamic basis*.[15]

The intelligent architectures advocated in the Advanced Logistics Program (ALP) prototyped by the Defense Advanced Research Projects Agency should be closely examined for applicability in this context. The ALP provides a generic "cluster" representing each unit or organization that has assets that contribute to employment capability. The cluster uses a "plug-in" with specific business rules and unit characteristics to create individual unit agents, which then interact with other unit clusters to dynamically replan support based on constraints specified by the plug-in. The flexible nature of this architecture has significant potential for a rapidly changing environment.

[15] AF/SC.

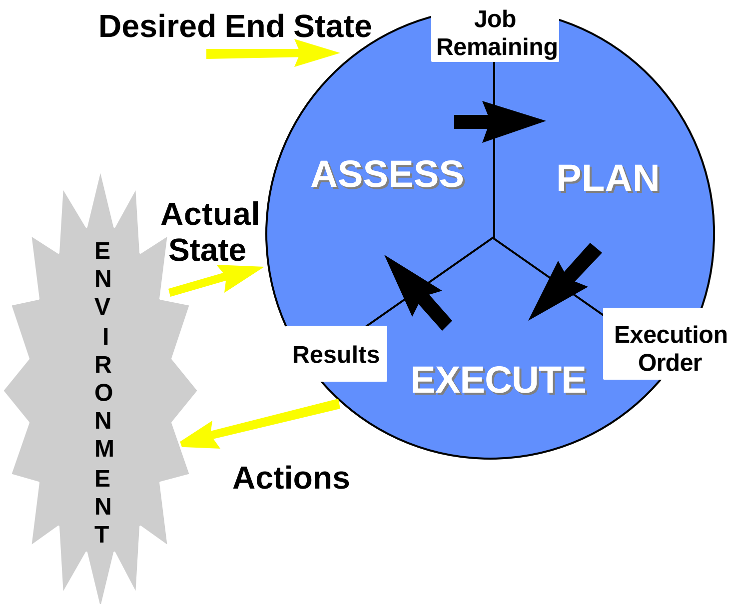

Figure 5-16. *Dynamic Replanning Model*[16]

5.2.4 Force Protection

Introduction

Protection from threats to both aircraft and personnel requires leveraging a number of technologies by the military in OOTCW situations. The '97 AEF report, Volume 3, Appendix I, "Environment (Biological, Chemical, and Force Protection)," provides a consolidated source of information on threat descriptions and joint program initiatives, and the panel endorses the findings of that study. This report addresses only threats unique to OOTCW and technologies or areas not covered in the 1998 report. Paradoxically, a humanitarian relief operation may face threats from civil disorder or other circumstances that are as severe as those confronting a combat AEF, but with far less force protection. Previous inter-Service agreements between the Air Force and Army gave responsibility for airbase defense outside the airbase's perimeter to the Army. Now the Air Force has responsibility for up to 12 miles outside the fence. Technologies are required to detect, warn, mitigate, and defeat threats that can arise from the use of biological, chemical, laser, or conventional weapons. Specific findings and recommendations relevant to the protection of personnel, aircraft, and equipment from such threats are outlined below.

Protection for Personnel

Technologies should be developed and employed to better protect personnel from the effects of biological, chemical, and laser weapons in the OOTCW environment. These technologies may be categorized according to their ability (1) to vaccinate and protect personnel against weapon effects, (2) to detect the presence of the weapon or its effect, and (3) to diagnose, treat, or decontaminate exposed or affected personnel.

With the escalating threat of biological and chemical weapons, it is essential that medical protection via pretreatment drugs be provided for Air Force personnel. Vaccines to protect against a variety of biological and chemical toxins are under development through the Army Medical Biological Defense

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[16] Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center.

Research Program. Promising molecular biological tools are being used, for example, to delete toxin-producing genes in bacteria and to boost production of protective immunogens in the human body. Examples of current and future vaccination practices may be found in the '97 AEF Study. Medicinal post-exposure treatments for personnel exposed to biological weapons must also be developed further; other than therapeutic drugs for endemic infectious diseases, there are not many options available.

Specific protection against chemical weapons currently includes individual protective equipment (IPE) which must be worn during times of chemical and biological warfare vulnerability. IPE wear typically results in significant discomfort, reduced performance due to heat stress, reduced manual dexterity, and restricted vision and communication capabilities. Aircrew ensembles have gone through several improvements while ground crew ensemble improvements lag behind. Improved IPE, particularly for ground personnel, should be made a higher priority by advancing the Joint-Service-Lightweight Integrated Suit Technology program.

Eye damage from the effects of laser weapons is an increasing concern and can be a widespread problem during an OOTCW situation. Commercial lasers are available from many countries, such as Germany, France, South Korea, Finland, Russia, and Bulgaria. Commercial lasers have proliferated to the point where U.S. Air Force personnel can expect to be targets in the future. Laser effects can result from weapon systems ranging from manportable (for example, the mallet fist and the M203 laser grenade dazzler) to mechanized (for example, the Chinese ZM-87). In addition to eye damage, lasers can cause significant problems within the cockpit such as canopy irradiation and head up display (HUD) glare, which prevent aircrews from seeing outside the cockpit or from seeing the HUD. Ongoing AFRL/Human Effects Directorate research into laser-hardened optics development for protective glasses and night vision goggles is particularly promising. Alternative methodologies that include using high-performance (switchable or tunable) optical filters, dielectrics, holograms, absorbing dyes, and chromophores should also be explored. The AFRL program needs continued funding to ensure further development and eventual fielding of agile laser eye protection. Protection against pulsed lasers, which can be particularly damaging to detectors, depending on the laser pulse width, via optical limiters (gas plasma cell and solid state) also requires further development.

Chemical and Biological Detectors Are Needed

Accurate and field-usable detection technologies are required for chemical and biological detection so that rapid and accurate response is possible. Long-range (beyond the fence) detection of chemical and biological agents is especially crucial to provide Air Force personnel advanced warning of an inbound "cloud." Currently, biological detector systems such as the Army Biological Integrated Detection System and Portal Shield provide indication of agents at the sensor site. These give personnel little to no warning time to don mission-oriented protective posture (MOPP) gear, and exposure occurs at the same time sensors are detecting a chemical and biological attack. While technologies currently pursued by the Army and Navy have promise (for example, laser detectors for tracking aerosol clouds, pyrolysis mass spectroscopy, and immuno-absorbent assays), they do not provide real-time operation. Real-time, accurate sensor and detector technologies need to be accelerated—especially those that can identify a wide range of biological agents. Possibilities include Micro Electro-Mechanical Systems- (MEMS-) based sensors used in conjunction with or independent of optical devices and satellite-based systems using spectral analysis. Ongoing research pertaining to laser remote optical sensing detection of chemical weapons at AFRL should be accelerated. The system's laser is eye safe and invisible, posing no eye or flash blindness hazard. Active optical Lidar concepts involving differential absorption and data fusion with passive sensors can lead to near–real time chemical (or possibly even nuclear, biological, and chemical) agent detection.

Diagnosis, Treatment, and Decontamination

Medical triage and diagnosis in the field can be greatly assisted by advances in the development of telemedicine systems such as those currently examined by the Army. "Health monitoring" identification bands or ID tags could allow a more rapid treatment of affected personnel than is currently available. Microscale sensors could also be incorporated into such ID tags for rapid health monitoring.

Decontamination of personnel exposed to biological or chemical weapons is currently limited, consisting of the M-291 Skin Decontamination Kit and the M-258A1 Personal Decontamination Kit. Also, little capability exists to decontaminate "dirty" MOPP gear prior to its removal. Development programs for decontamination technology appear to be too long term in emphasis. Commercial off-the-shelf (COTS) technologies for chemical decontaminants and disinfectants should be actively explored. The company OWR/USA, for example, developed—and has fielded with several militaries worldwide—a decontaminant called GD-5, which is advertised to decontaminate all known chemical and bacteriological agents, and is nontoxic and noncorrosive. Direct emulsion decontaminants could also be used against radioactive fallout. Decontaminants such as GD-5 need to be tested as soon as possible to determine their effectiveness. If aggressive testing programs yield an effective decontaminant, procurement and fielding should quickly follow.

Even a decontaminant that does not completely fill the Joint Operational Requirements Document (JORD) for the Joint-Service Sensitive Equipment Decontamination (JSSED) requirements could present an interim solution to many problems. Current procedures require potentially contaminated personnel in MOPP gear to pair up in a buddy system to safely take off their IPE. If they are in a contaminated environment, or have contaminated IPE, potential exists for the personnel to become contaminated during equipment doffing. A notional CONOPS might solve this problem by putting all personnel entering a collective protection shelter in an enclosed "transition" room first. A decontaminant, like GD-5, could be used to "fog" the room. When the chemical and biological agent(s) have been decontaminated, personnel could safely remove their IPE without fear of contamination and enter the shelter with "clean" IPE. Another notional CONOPS could take advantage of the decontaminant along with long-range detection equipment. An array of decontaminant "foggers" could be deployed to ring threatened aerial ports of debarkation, or a "crop duster" unmanned aerial vehicle approach could attack threat clouds. If a chemical and biological cloud were detected, the foggers could be used to dispense decontaminant into the plume as it passed over the array, effectively decontaminating it before it descended on personnel and equipment. While there are no current data on such a system, the Air Force should explore the feasibility and effectiveness of fogging the threat clouds prior to the contamination of assets.

Special emphasis should be given to the decontamination of injured personnel. This capability is especially important when theater medical air evacuation is required. Close coordination between the Army and Air Force medical and air evacuation personnel is required.

Protection for Aircraft and Equipment

Advances in space surveillance systems capable of detecting chemical and biological clouds should continue to be pursued. Satellite-tracking telescopes, active imaging trackers, and Fourier telescopy techniques can be of benefit for early detection. Detection of the effects of chemical or biological weapons could also be advanced using optical or MEMS-based systems, as noted above for personnel protection.

Defensive systems, including IR countermeasures (IRCM) and ALE-50-like equipment, are required for heavy aircraft to counter MANPADS and RF missiles. There are more than 100,000 SAMS worldwide, and these pose a significant threat to mobility airlift forces because of the lack of current multithreat defensive systems. The AFSOC Large Aircraft Infrared Countermeasures (LAIRCM) Advanced Technology Demonstrator is seeking to remedy this problem through an integrated threat-warning,

prioritization, countermeasure application, and threat-miss verification system. A study should also be conducted to examine the feasibility of a podded defensive system for heavy aircraft that employs lasers, towed decoys, or other technologies to detect and defeat threats. Possible technologies include IRCM systems, which can provide an early missile and aircraft warning capability in addition to precision tracking, pointing, and jamming. Closed-loop IRCM systems, such as the AFRL LAIRCM program, with real-time sensing, feedback, and jamming are particularly impressive and could be developed for near-term implementation. The cost of installing missile warning laser countermeasures and towed decoy systems on large aircraft is high (estimated at about $10 million per aircraft). Podded systems could eventually be employed fleet-wide or be temporarily used on selected aircraft entering high-threat areas to decrease system costs.

The requirement for an "Aircraft Interior Decontamination System" dates back to Jun 89 and Military Airlift Command. The requirement is now covered in the draft JORD for JSSED. Current JSSED completion estimates run to the 2007–2008 timeframe. In the interim, interior and exterior decontamination capabilities for aircraft and equipment that are exposed to chemical or biological weapons remain limited.

Current procedures involve either washing equipment with a 5 percent bleach solution or using a high-pressure washer and hot soapy water. The capability to quickly decontaminate aircraft interiors and sensitive equipment is almost nonexistent. Current procedures involve either allowing the aircraft to weather or to fly unpressurized to effectively increase the weathering effects. In addition to the problems posed by not having an effective decontaminant, AMC strategic airlift aircraft face another challenge: no national or international standard of cleanliness for decontamination exists. These strategic airlift assets could be lost indefinitely once they are contaminated.

The U.S. Air Force should push for testing of existing COTS and developmental decontaminants and should accelerate the closure of the JSSED. Once an acceptable decontaminate is found, it should be quickly funded and fielded.

5.2.5 Sustainment

Introduction

For purposes of this study, the logistics dimension of OOTCW has been divided into mobility and sustainment. Sustainment, in turn, is addressed in two fundamental senses:

- Maintenance and modernization of the systems and equipment used to deploy and sustain aerospace forces
- Logistics support to forces at home, en route, and at deployed operating locations

OOTCW situations create sustainment demands that have many features in common with combat operations but also have a number of significant differences. Sustainment of AEFs was treated in detail in the '97 AEF Study, Appendix H, "Lean Sustainment." This chapter summarizes the key features of deployed logistics with emphasis on the unique challenges of OOTCW.

Sustaining Systems and Equipment

The ability to execute any aerospace operation, from MTW to OOTCW, depends on the availability, supportability, and reliability of the assets employed. Everything from transport and tanker aircraft to MHE and portable communication gear must be ready to go and operate reliably when called upon. Like every element of the current force structure, mobility and support systems are plagued by shortfalls in their underpinning logistics, and the situation is complicated by high OPTEMPO, which accelerates

equipment wear out and consumes precious support resources. Two examples from the thousands that could be cited are

- Spare parts shortages exacerbate problems with low C-5 reliability
- Items such as tents and furniture in long-term storage often prove unserviceable when needed because of mildew, corrosion, or other deterioration

The ’97 AEF Study addresses a number of problems in this area, including the following:

- Chronic underfunding of spares and repairs accounts, coupled with inadequate tools for demand forecasting. As noted elsewhere in this report, this leads to reduced MC rates that make the effective force considerably smaller than the on-the-books inventory suggests.
- Less-than-desired engine reliability, which affects older transports, such as the C-5, just as it does fighters and bombers.
- The need for focused reliability and maintainability improvements based on valid failure data and the analysis of fixes that have high leverage on MC rates per dollar invested.
- The need to aggressively push progress along the many dimensions of lean logistics, including enhanced contractor repair times, time-definite delivery of materiel, operating sites, and effective logistics reachback.

The recommendations of the ’97 AEF Study are, for the most part, relevant to the present topic and deserve renewed attention. In the sustainment area, several ongoing studies in such areas as war reserve materiel posture and support equipment for smaller deployable packages are under way, but to date implementation has been limited.

We stress that all categories of equipment, not just aircraft, require attention to correct sustainment deficiencies. Vehicles, K-loaders, field hospitals, deployable C^2 nodes, Harvest kits, and a host of other systems and equipment types need periodic maintenance and assured availability of spare parts just as much as more “glamorous” assets. The lack of a repair part for a forklift or K-loader can cause as much of a problem in shutting down a small airhead (typical of many OOTCW scenarios) as a broken airplane blocking the ramp. As the Air Force transitions to an expeditionary paradigm, and as OOTCW become increasingly prominent, the sustainment of mobility and support systems should receive proper priority within a balanced program.

Sustaining Forces

It is essential that the primary combat support functional areas operate in an integrated planning and management structure that ensures that the operational force, in combat or any other mission, receives timely, seamless, and efficient support. These functional areas are as follows:

- Transportation—surface and air movement on and in the vicinity of an operating base or site
- Maintenance and munitions—preparing aircraft for missions
- Communications and information—the equipment and processes that coordinate operations
- Comptroller, legal, and local contracting—essential functions in many situations, especially when support is drawn from the local area
- Personnel—administrative support to the troops.
- Services—housing, food, recreation, mortuary services, and other aspects of caring for the troops
- Supply—requisitioning, storing, issuing, and accounting for consumables and replacement materiel

- Security—force protection, access control, law enforcement, and other aspects of threat negation
- Civil engineering—everything from pavement to waste disposal associated with establishing and operating a facility
- Weather, safety, medical, and other specialized services
- Logistics plans—the nerve center of operating a deployed site

OOTCW can put stress on sustainment in ways that are different from combat situations—and may actually be worse. For example, conducting relief operations in a country where law and infrastructure have been abolished by civil strife or a major disaster is likely to create security hazards while making normal use of force difficult. It is not hard to imagine the impact of CNN showing American security forces firing on a mob of starving locals trying to break into a base. Other challenges arise in creating refugee camps, delivering high volumes of food and relief supplies into confused circumstances, and treating a large population of sick and injured. In combat operations, sustainment airlift is normally into an established airhead on a base where high sortie rates are being maintained, but OOTCW may require retail deliveries to extremely austere and remote airfields. Operation Restore Hope in Somalia provides a classic example.[17]

Recent experiences suggest that the Air Force is not as ready to sustain some types of OOTCW as it could and should be. For "short and sharp" operations like a hostage rescue, sustainment is not much of an issue. Missions such as intelligence, surveillance, reconnaissance, and enforcement of no-fly zones are close enough to combat operations that they benefit from preparations for the primary AEF model of aerospace force employment. Here, the shortcomings and recommended corrective actions identified in the '97 AEF Study pertain to both combat and OOTCW situations. However, HUMROs, NEOs, and other OOTCW, especially if they last more than a few days, are likely to highlight the reality of inadequate preparation and training. In general, the Air Force does not invest in the assets needed for long-term support to large populations. In fact, the Air Force will usually be in a supporting role to government and private organizations in areas such as transportation and security.

One of the major recommendations of the '97 AEF Study also has great potential to improve OOTCW. This is the establishment of a global network of RCCs at carefully selected locations. As few as eight properly sited RCCs would put almost all of the areas where operations are likely within an unrefueled theater transport sortie of a main operating base. An RCC is a major military or civilian airfield where the United States establishes guaranteed access, makes facility preparations to support rapid buildup of operations, and prepositions low-cost bulk cargo that can survive in static storage. In a contingency, air mobility forces would conduct a hub-and-spoke operation with strategic airlift flow into the RCC and tactical retail airlift to points of delivery. This would allow maximum flexibility in use of available lift and support equipment. Prepositioned supplies would speed response to a crisis and reduce at least the initial strategic lift requirements. For example, in a disaster relief operation, the RCC could be the site of a major hospital, supporting field teams delivering urgent care. The RCC would be the logical destination for private relief delivery and could greatly ease problems such as ATC and limited ramp space at austere forward fields. Figure 5-17 shows that as few as eight RCCs would put most areas of interest within unrefueled round-trip range of C-130 or C-17 sorties.

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17 *Airhead Operations: Where AMC Delivers the Linchpin of Rapid Force Protection*, Lt Col John L. Cirafici, Air University Press, 1995.

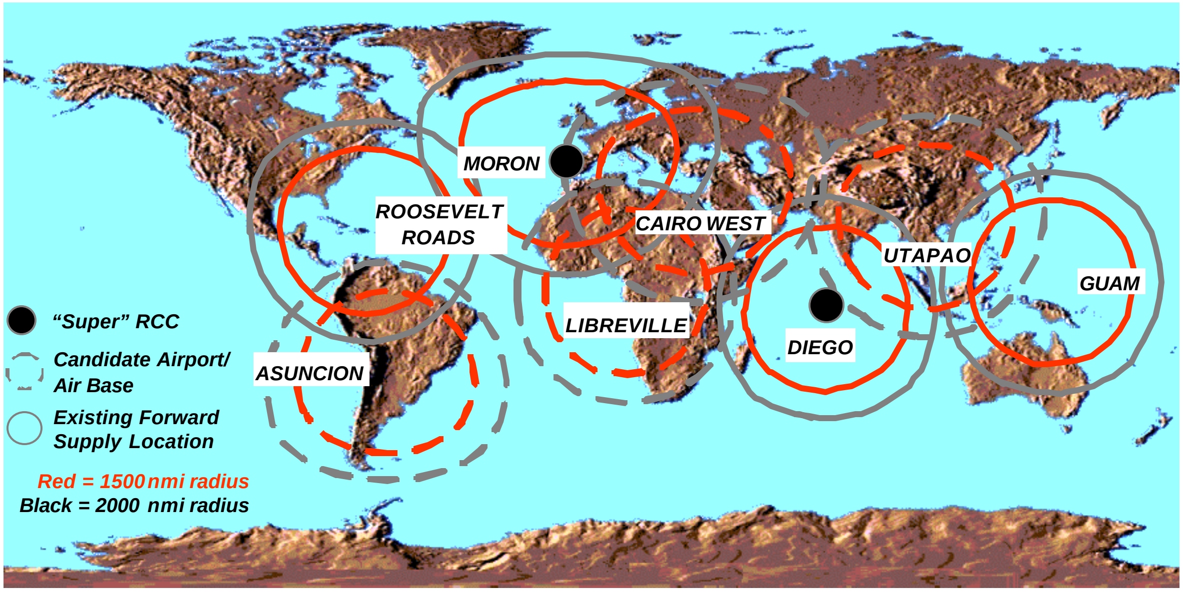

Figure 5-17. *A Small Set of Properly Chosen RCC Locations Provides Nearly Global Coverage*

Improving Sustainment

The Air Force needs to deal with the reality of a wide range of OOTCW missions, to clearly define each mission category, and to identify the capabilities required in each situation. The Air Force should conduct a thorough and unbiased appraisal of current status, including exercises that realistically stress people and equipment, and should give proper priority in the budget to the correction of deficiencies in the context of the overall program. In particular, the Air Force should continuously seek the most cost-effective ways to meet sustainment needs. One component of this is a program with a focused technology base that both maintains awareness of the state of the art and invests in high-leverage (usually military-unique) areas. Examples range from improved shelters and base services equipment to smaller, more rugged MHE. Depending on the equipment category, the preferred approach may be a COTS purchase, joint programs with other Services, or refurbishment of existing inventory.

Other sections of this panel report address actions to increase the effective number of available airlift aircraft. The panel has identified a number of additional measures affecting ground equipment and other parts of the sustainment "machine" that would further improve the ability of the Air Force to execute and support OOTCW. An important one, which has been the subject of considerable R&D and many previous SAB recommendations, involves accurate point-of-delivery airdrops. The Kosovo crisis has furnished yet another instance in which such a capability would have been of immense value. We believe that an affordable Global Positioning System- (GPS-) guided airdrop kit could be developed. A parachute system would be useful for conventional landing and offloading, for example, in delivering larger quantities of food under conditions of low threat but limited airfield availability. The panel talked to a number of operational personnel who believe that point delivery with standoff range is needed in threat areas where overflight is not feasible.

Another well-known and high-leverage concept is that of an Autonomous Landing System for operations in near-zero visibility at austere sites. This and other initiatives of the AMBL of the AMWC have the potential for affordably improving Air Force capability to sustain combat and noncombat operations.

A perennial concern involves MHE. If loaders, forklifts, trucks, and other MHE are not available when and where needed, all the transports in the world will not do the job. The panel saw a demonstration of

the new Tunner 60-K loader and its exceptional flexibility in rapidly loading and unloading a variety of aircraft, including CRAF transports. A concern has been raised that use of Tunners in the transporter role, that is, to move cargo long distances as well as into and out of aircraft, will shorten their lives and cost more than trucks and trailers. The Tunner is too new for an assessment to be made, but the Air Force should carefully track its reliability and support costs in various modes of employment to avert a problem. Furthermore, although the Tunner is a marvelous machine, it is big, expensive, and transportable only on heavy airlift aircraft. The NGSL is to be C-130 transportable and would be of great value in many OOTCW where heavy cargo is seldom involved but loading and unloading at numerous austere airfields is routine. The Air Force should rapidly procure and field the NGSL.

The general theme of improving deployability and sustainability by modernizing current equipment to reduce size and weight came up many times in the course of the Deployment and Sustainment Panel's information gathering. A good example is deployable ATC equipment. One estimate is that the communications, data processing, and other equipment of an ATC center today fill roughly five C-5s. This amount of airlift represents a significant fraction of even a large AEF. The panel believes that migrating to available hardware, for example, ruggedized commercial computers, could significantly reduce this total. For example, the '97 AEF Study concluded that the existing wing initial communications package, which has communications and data processing content similar to an ATC center, could be shrunk by nearly half in the short term, by adopting modern equipment, and ultimately by 75 percent, even while significantly increasing performance.

To truly maximize sustainment in a severely resource-constrained environment, the Air Force should consider even more radical approaches. An example involves the way logistic support is provided to strategic airlift. Today, each airlift mission design series is either assigned to an Air Logistics Center or supported via contractor logistic support. In either case, the system is intended to provide the spare parts, programmed depot maintenance, system upgrades, and other support to maintain a certain MC rate across the fleet as well as to support day-to-day operations and maintenance. The Government is centrally involved in everything from forecasting the demand for spares to planning and managing system modifications. Suppose instead that a commercial model were applied to the problem of assured airlift capacity. A typical approach would be to award a contract under which the contractor assumed responsibility for managing the fleet and would be committed to an operational outcome such as a guaranteed schedule of daily departures with appropriate financial incentives based on how well the goal was met. The contractor would have the freedom to do anything from setting spares inventory to reengineering the fleet. Many more opportunities for this sort of improvement are possible.

Summary

Sustainment of support equipment and deployed forces is likely to be a major limiting factor in both combat and OOTCW. Much of what needs to be done has been identified in earlier SAB studies, notably the '97 AEF Study. However, some OOTCW present different challenges, and the current focus of the Air Force on combat AEF operations may hinder the process of defining requirements and acting to achieve the corresponding capabilities. Both exercises and real-world operations can provide valuable data to assess the ability of the Air Force to execute these missions. The necessary commitment to this increasingly important aspect of aerospace power is essential and must be recognized in budget priorities.

5.2.6 CSAR

The Deployment and Sustainment Panel examined the CSAR mission as part of its study effort. The CSAR mission highly leverages the aerospace power associated with OOTCW as well as with conflict associated with MTW. Therefore, the CSAR mission has an important overall impact on the success of the GEO construct.

The organization, training, and equipment of the CSAR force have changed many times over the past decades. Within the DoD the CSAR mission has been the responsibility of the individual Services. Within the Air Force, the CSAR mission has varied from a separate service to an adjunct to a major air command with many names and locations over time. The mission enjoyed its greatest visibility and success during the Vietnam War when many downed aircrews were successfully rescued from hazardous circumstances to return to fight another day. The Vietnam era contrasts with an almost total absence of capability before Desert Storm.

Currently, the CSAR mission is assigned to the ACC. CSAR units operate HH-60 helicopters and are assigned to the active duty (52 percent) and Guard and Reserve forces (48 percent). The active forces are located at Moody Air Force Base (AFB), Nellis AFB, Kadena, and Keflavik, Iceland. The Guard and Reserve forces are located in Alaska, New York, California, and New Mexico. Today's HH-60s possess considerable capability, contrary to the perception that they are effective only in daylight visual flight rules environments.

The current HH-60 (-142) configuration has an integrated navigation suite including GPS/Inertial Navigation System, forward-looking infrared, weather radar, an ALQ-144 IR jammer, three gun mounts, and chaff and flare capability. Upgrading of 49 of the 105 HH-60s has begun (with the first delivery in April 1999), which improves the external gun mounts, adds an improved digital avionics package, adds a plume detector, and adds an automatic chaff and flare dispenser system. The remaining service life of the other 56 HH-60s precludes the upgrade modification. The panel concludes from this that the CSAR forces have sufficient equipment.

The other force that possesses CSAR capability is the AFSOC under the U.S. Special Operations Command. During the development of joint doctrine for special operations, certain legislated special operations activities were refined into the principal special operations missions. Other legislated activities and missions frequently assigned by geographic CINCs fall under the heading of "collateral activities." The SOF may conduct several missions and collateral activities at the same time in a single campaign. The CSAR mission for AFSOC is a collateral activity defined as a specific task performed by rescue forces to effect the recovery of distressed personnel during wartime or contingency operations.

The AFSOC forces consist of uniquely equipped MH-53J Pave Low III and MH-60G Pave Hawk. The primary advantage of the MH-53 is a weather penetration capability using terrain following, terrain avoidance (TF/TA) radar, digital link in the multifunctional advanced tactical (MATT) terminal, and plume detectors. The MH-60s also have the MATT terminal for threat data. Of course, in a high-threat area, the TF/TA radar on the MH-53 radiates a significant radar signature that abdicates some of its all-weather capability. This helicopter force is to be replaced by the CV-22.

Training of the two CSAR-capable forces differs significantly. ACC CSAR training is integrated with the blue Combat Air Force (CAF). The training is integrated into larger strike forces and includes the A-10 Sandy, F-16 CJ, and EA-6B for mission prosecution. Although equipped with lighter area suppression weapons, the CSAR force uses the A-10, F-16, and F-15Es to do their heavy work. Their tactics are based on those forces pre-sanitizing the landing zones. The SOF training concentrates on short-, medium-, and long-range insertion, extraction, and resupply missions in hostile territory. SOF are better trained for their core missions described above, but not to do CSAR. SOF do not train with the blue CAF. They are not integrated with the larger strike packages. Over the past few contingencies, SOF have been successful at CSAR because AFSOC helicopter pilots are competent and experienced in rescue operations. The SOF training mission profiles rely on an "alone and unafraid" concept, which normally requires 72 hours for mission preparation. The CSAR mission focuses on rescue-only requires sitting long-term strip alert and immediate response to "stark raving terror" requirements. Another important training difference involves pararescueman (PJs) training conducted by each command. The SOF PJs

require a more intense medical qualification that polarizes the two groups, causing morale, assignment, and personnel problems.

The panel observed that ACC is conducting an AOA to determine the optimum number and type of aircraft to perform the CSAR mission. Candidates such as the CV-22, S-92, or improved HH-60 are being examined. The output of the study will determine a long-lead funding line for the selected aircraft. SOF plans to replace their helicopter force with the CV-22 are underway. With only 49 of 105 HH-60s programmed to remain in the ACC fleet and with the delivery of the CV-22s not taking place until approximately 2007, there will be a significant decrease in credible CSAR capability. Therefore, the AOA at ACC should also determine the number of aircraft required to perform the CSAR mission.

The panel recommends a high-level review to determine whether the CSAR-capable forces of ACC and AFSOC should be combined under one major command (MAJCOM). The specific organization that a consolidation would require is a decision for the CJCS, the Air Force Chief of Staff, and the Secretary of the Air Force. These would need to coordinate with the warfighting CINCs, which must understand the implications of such a decision. Efficiencies in logistics, training, personnel, and beddown could be achieved. More importantly, the CINCs, the EAF strike force, and complementary elements would be supported by a robust CSAR force with homogeneous training and capability.

5.3 Conclusion

5.3.1 Panel Findings

The U.S. Air Force has high hopes for its capabilities to project national power in the 21st century, as illustrated by the EAF construct. If this happens, deployment and sustainment capabilities must be advanced in parallel with those that they support. Only if the Air Force improves its deployment and sustainment capability will there ever be a true EAF.

The logistic system that the Air Force has now will not meet its future goals. In particular, the OOTCW logistic capabilities must be improved; in many cases these improvements are not realized by preparing better for MTWs. We have found that airlift capacity must be improved for the unique demands on the active force that OOTCWs provide. In addition, planning systems must be integrated with execution systems in order to meet timelines and airlift capacity. Sustainment must receive renewed attention to make deployment faster. The proliferation of viable threats from areas where OOTCWs will likely be conducted demand countermeasures and sensors. All these improvements will allow the Air Force to better accomplish its missions in a changing world.

5.3.2 Summary of Recommendations

The following is a list of the recommendations discussed in the Deployment and Sustainment Panel report:

Continue Transition to Implement the EAF

- Include realistic logistics planning in exercises and training.
- Equip for and exercise OOTCW-unique mission aspects.
- Transfer equipment packages between deploying and redeploying units.
- Explicitly acknowledge the logistics functions of elements in the Respond phase of GEO.
- Establish real-time connectivity for data transfers with air-mobility aircraft, such as the major airlines have.

- Improve international and civilian airlift coordination structures for OOTCW missions such as HUMROs.
- Incorporate logistics processes in every phase of GEO.

Increase Airlift Capacity for OOTCW

- Calculate both peacetime and wartime requirements, and base the airlift force structure on the larger (former) requirement.
- Replacement units should use the previous unit's equipment (that is, people should be moved, not equipment).
- Structure the TWCF in a way that establishes incentives for the efficient use of airlift.
- Reevaluate the active-reserve mix.
- Increase the active duty crew ratio.
- Modernize the C-5. Using cost-benefit analysis, determine the optimal cost-effective reliability for the entire airlift fleet, and adjust budgets and the force structure to that ratio.
- Install C-17 center wing tanks fleet-wide.
- Continue the C-130 AMP program to standardize the C-130.
- Accelerate the KC-135 multipoint, soft-basket refueling capability to free up KC-10s.
- Examine alternative maintenance concepts for the KC-135 fleet that reduce depot time (see the *1994 SAB Aging Aircraft Study*).
- Procure the optimal combinations of C-130J-30s and C-17s to enhance strategic lift capability.
- Examine C^2 relationships between the U.S. Transportation Command and theater CINCs in light of the new capabilities of the air mobility fleet (for example, the C-130J-30 and the C-17's inherent capability to do both strategic and tactical missions).
- Continue to pursue modern simulator technologies that will be acceptable as alternatives to flight time training requirements.
- Reassess the level of airdrop training required and its priority.

Integrate All Planning and Execution Systems

- Develop planning architecture and define and standardize interface requirements before the planning modules are built.
- Generate deployment requirements using automated expert systems, then have them validated by the CINCs.
- Develop automated tools that select optimal deployment and employment locations, generate requests for facility use, and identify the need for diplomatic clearances.
- Develop and deploy information system tools to enable customers at all echelons to effectively prioritize movement requirements according to available movement capacity.
- Where possible, optimize transportation, for example, choose geographically proximate force elements and alternative transport modes to reduce in-transit times.
- Rethink core UTCs: develop a set of core EAF UTCs or force packages for typical deployment (for example, a six-ship fighter slice or a HUMRO package) and greatly improve the ability to tailor and integrate them. Use an expert rule base that allows incremental building and tailoring.

- Size spares and support packages for shorter deployments (3 to 7 days versus 30 to 60 days) with planned follow-on logistics support.
- Produce and maintain a virtual integrated database of logistics data (forward-deployed resources, local contract sources, host nation support) that allows planners to systematically perceive and source shortfalls.
- Develop planning tools to provide real-time visibility and the condition and status of assets available at operating locations, forward support locations, and continental United States (CONUS) bases and depots. Planning tools must identify planned use of these assets to facilitate deploying-force decision making.
- Continue development of service "feeder" systems that provide accurate UTC data for airlift planning (DCAPES).
- Apply an IDS (the IDS practiced at Eglin AFB is an excellent model) to cargo, specifically to provide individual deployment work centers a tool to develop detailed pallet inventories. The best technical solution now is the inexpensive but data-rich 2-D barcode format. Base LAN connectivity is needed to feed this information to central planning systems. C^2 Information Processing System needs configuration control and backward compatibility to IDS.
- Continue to develop a Time-Phased Force Deployment Document that allows deployment in an hour, but integrate it to future systems.

Give Higher Priority to Protection From Threats to Both Personnel and Aircraft

- Develop and install systems on heavy-aircraft to counter MANPADS, other IR missiles, and RF missiles (including ALE-50-like equipment).
- Conduct a feasibility study to examine a podded defensive system for heavy aircraft that employs lasers, towed decoys, or other technologies to detect and defeat threats. These could be eventually employed fleet-wide or on selected aircraft to reduce total system costs.
- Develop the capability to quickly decontaminate large aircraft.
- Develop and implement timely and effective sensor technologies; possibilities include microscale devices, optical, satellite, directed-energy, passive point, chemical, and spectral analysis systems.
- Explore the possibility of using fog decontaminants against chemical clouds.
- Examine COTS decontaminants (such as GD-5) immediately.
- Develop vaccines against likely biological agents.
- Continue to develop multispectral laser eye protection technologies.
- Field biological diagnosis and telemedicine.
- Field medical "smart ID tags."

Improve Sustainment Capability

- Develop point-of-delivery airdrop for situations where conventional landing and offloading are not practical. Pursue affordable methods to accomplish this from standoff ranges for situations where threats preclude overflight.
- Develop Autonomous Landing Systems for near-zero visibility at austere sites.
- Determine the future of the AMWC "Battlelab" (grow to full battle lab status?).

- Provide real-time visibility and the condition and status of assets available at operating locations, forward support locations, and CONUS bases and depots in planning tools. These tools must identify planned use of these assets to facilitate deploying-force decision making.
- Ensure that mobility assets are properly prioritized in funding allocations while continuing to work the overall problem of adequate spares and repairs budgets.
- Conduct a study of the feasibility and payoffs of applying commercial models to the delivery of airlift capacity.
- Improve the design and maintenance of the systems and equipment used at the point of delivery, including base support, personnel support, transportation, MHE, POL, and others.
- Pursue a balanced program of technology development, selective acquisition of COTS, joint programs, and others to improve the size and weight, durability, and operational suitability of deployment equipment (for example, shelters, power production, and POL).
- Take steps to ensure that Harvest kits and other deployment materiel are properly stored, maintained, and refurbished, and include periodic inspections and exercises.
- Track reliability and maintenance of Tunners to determine the effect on long-term unit life and support costs.
- Procure an NGSL to provide a reliable loader transportable by C-130s.
- Adhere to the recommendations on this subject in the '97 AEF Study.

The Air Force Must Ensure That Its Forces Can Appropriately Fulfill the CSAR Mission

- Expeditiously complete the AOA for determining the optimum numbers and types of aircraft to provide timely and effective CSAR.
- Conduct a high-level review of CSAR organizational alternatives, including the combining of ACC and AFSOC resources into one MAJCOM.

Appendix 5A

Deployment and Sustainment Mission Statement

The tasking to the Deployment and Sustainment Panel was as follows:

- Identify deployment and sustainment issues and needs unique to OOTCW
- Assess current and planned Air Force capabilities against these needs and the staff provided OOTCW vignettes
- Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
- Postulate evolutionary and revolutionary options and technologies for meeting these needs
- Include
  - Concepts for precision air delivery of fuel, food, water, medicine and other supplies to military and civil users
  - NEOs
  - Non-combat rescue, combat rescue, and refugee movement
- Consider relationship to Expeditionary Air Forces concepts
- Assess revolutionary lift and logistics concepts
- Coordinate closely with the Lethal and Non-Lethal Effects Panels

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Appendix 5B
Organizations Consulted

21st Air Force

621st Air Mobility Operations Group

AF/IL

Air Combat Command

Air Force Research Laboratory

Air Force Special Operations Command

Air Mobility Command

Air Mobility Warfare Center

Defense Logistics Agency

Department of State

Office of Foreign Disaster Assistance

DOMS

Joint Operations Division, EUCOM

Joint Staff, J-4, Deployment Division

Joint Staff, J-4, Logistics Information Systems Division

Joint Staff, J-4, Logistics Readiness Center

Joint Staff, J-4, Sustainability, Mobilization, Plans, Exercises

Red Horse

United Nations High Commission on Refugees

U.S. Pacific Command

U.S. Southern Command

U.S. Special Operations Command

U.S. Transportation Command

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Chapter 6
Non-Lethal Effects

6.0 Introduction

6.0.1 Background

Non-lethal warfare is fast emerging as an important new arrow in the warrior's quiver. DoD has established policy[1] for non-lethal weapons, defense plans have decreed that non-lethal weapons must be considered in planning, and the Joint Non-Lethal Weapons Directorate (JNLWD) has been established, with the U.S. Marine Corps as DoD executive agent, for the development of equipment and procedures.

Non-lethal warfare should not generally be considered as an alternative to lethal warfare but as an element of a continuum of lethality at the hands of the commander. The panel found that the range of opportunities to apply levels of non-lethal weapons to operations other than conventional war (OOTCW) is exceptionally broad and is an area not adequately addressed by either planners or developers within the Air Force. Moreover, it is important to recognize that most operators will not risk the use of non-lethal weapons if they have not been trained in their effects and do not understand their employment.

6.0.2 Scope

The DoD Defense Planning Guidance[2] establishes the basis for including non-lethal weapons in plans, concepts, and operations:

> *Non-lethal weapons have proven useful across the range of operations, including both conventional combat operations and the many categories of military operations other than war [MOOTW] … Current efforts to study and understand the use of non-lethal weapons from the strategic to the tactical levels must be integrated into all future military and interagency concepts and operations.*

Non-lethal weapons have gained attention since the end of the Cold War and the shift in DoD to MOOTW. While the term "non-lethal weapons" has been liberally used, it is not yet so commonplace that a standard definition is universally understood. Thus, the first order of business for the Non-Lethal Effects Panel was to define precisely what is meant by "non-lethal weapons" and to determine what constraints limit their application. Expected limitations on the use of non-lethal weapons will be addressed in detail in subsequent sections of this chapter. The definition of non-lethal weapons will be restricted to the current official version. The most recent official definition of non-lethal weapons comes from the DoD Directive (DoDD) 3000.3, which states:

> *Non-Lethal Weapons*—Weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to **personnel**, and undesired damage to property and the environment.
>
> 1. Unlike conventional lethal weapons that destroy their targets principally through blast, penetration and fragmentation, non-lethal weapons employ means other than gross physical destruction to prevent the target from functioning.

[1] DoDD 3000.3, "Policy for Non-Lethal Weapons," 9 July 1996.

[2] Ibid.

2. Non-lethal weapons are intended to have one, or both, of the following characteristics:

    a. They have relatively reversible effects on personnel or materiel.

    b. They affect objects differently within their area of influence.[3]

This definition contains an important phrase relating to use: "incapacitate personnel … while minimizing fatalities," which suggests that some fatalities could occur (that is, non-lethality is not guaranteed). A similarly important phrase regarding use in an antimateriel role is "non-lethal weapons employ means other than gross physical destruction to prevent the target from functioning" (that is, some level of destruction of the materiel is likely). Other vague phrases such as "intended to" and "relatively reversible effects" are included. There is apparently some latitude in the actual effects as long as the intent is to minimize injury or damage.

Panel Process

The panel visited various commands—U.S. Special Operations Command (USSOCOM), U.S. Southern Command, U.S. Central Command, U.S. Atlantic Command[4], Air Force Special Operations Command (AFSOC), Air Intelligence Agency (AIA), and Air Combat Command—to gain their perspectives on the use of non-lethal weaponry. To varying degrees, these commands and agencies were active in their thinking on the matter and, in some cases, actual planning was in progress. The panel also visited the Armament Center and Laboratory at Eglin Air Force Base (AFB) and the Directed Energy Directorate at Kirtland AFB, Sandia Laboratories. The panel received briefings from the JNLWD, the Army Armaments Center, and the Air Staff. The Office of the Secretary of Defense (OSD) filled the panel in on policy and law that relate to the development and use of non-lethal weapons.

The panel then reviewed operational tasks for OOTCW to determine where particular technologies might be applied, particularly for the developed vignettes. The panel spent time with the development agencies in the Air Force and Army and heard from the JNLWD. The panel investigated technology programs to the extent that security allowed and developed technology solutions that could be implemented. It was then possible to pair specific applications approaches (delivery methods) available to the Air Force with the technologies that might be used and, from that, provide recommendations to the Air Force for research and development (R&D) initiatives.

6.0.3 Strategic Vision and Plans

The Air Force can and will be a major component of the nation's capability in future OOTCW. Its strategy, vision, and plans must reflect how aerospace power can contribute, using non-lethal weapons and means, maintaining Air Force relevancy in the 21st century. Toward that end, Air Force leaders must be educated on non-lethal weapons, and aerospace-delivered non-lethal weapons must be included in the development of Air Force capabilities. During the course of the panel's study, no such strategy, vision, or plans were found to exist within the Air Force.

There is general recognition that the changing national security environment provides opportunities to use non-lethal means and weapons. The DoD has promulgated DoDD 3000.3, which sets the policy for non-lethal weapons. The Services are responsible for the "development and implementation of employment concepts, doctrine, tactics, training, security procedures, and logistics support for fielded non-lethal weapons systems." The policy excludes information warfare (IW), which is covered in a specific directive. The Air Force has non-lethal responsibilities diffused within the Air Staff.

[3] DoDD 3000.3, "Policy for Non-Lethal Weapons," 9 July 1996.

[4] Now called U.S. Joint Forces Command (USJFCOM).

The Marine Corps has been designated as the executive agent for the DoD non-lethal weapons program, and its organization, the JNLWD in Quantico, VA, will develop and recommend to DoD a fully integrated and coordinated non-lethal weapons program, will provide the most current and accurate information available, and will provide the best non-lethal weapons technologies and equipment to support the operating forces.

6.1 Discussion

6.1.1 Considerations in the Use of Non-Lethal Weapons

The introduction of any new weapon, tactic, technique, or procedure to the military Services must pass through many hurdles on its way to acceptance and standard use. These hurdles include bureaucratic, operational, acquisition, and normative issues. Bureaucratic issues involve policy decisions and legal constraints. Operational issues include formal integration into doctrine, establishment of appropriate rules of engagement (ROE), and training. Other hurdles are acquisition-related—for example, design specifications, effectiveness evaluations, and safety—while normative issues involve cultural acceptance by the user as well as the public. Non-lethal weapons offer issues that differ from their lethal counterparts in each of these areas.

Bureaucratic Issues

As a new form of force employment, non-lethal weapons must be defined and assigned. DoDD 3000.3 has provided the initial step in this process, providing a guiding definition and assigning relevant oversight responsibilities at the Under Secretary of Defense and Assistant Secretary of Defense levels, with responsibility for most implementation actions residing with the secretaries of each military department and the Commander-in-Chief of the U.S. Special Operations Command. While the bureaucratic issues are largely answered by DoDD 3000.3, there are still many such issues to be addressed within each military department.

DoDD 3000.3 demonstrates the breadth of policy issues addressed but makes it obvious that the actual implementation of any non-lethal weapon system rests squarely with each military Service. How and to what extent each Service implements non-lethal weapon systems will largely be a factor of operational, acquisition, and normative issues.

Operational Issues

The process of fully integrating a new weapon system into a fighting force takes years. The initial development of doctrine and inclusion in training exercises is accomplished rather quickly; however, the iterative process of developing mature tactics and techniques is ongoing. While this cycle is common to both lethal and non-lethal weapons, the development of appropriate ROE is likely to be much more difficult for non-lethal weapons, as this emerging capability presents a radically different approach to the application of force than the more traditional lethal weapons. The development of effective ROE deserves special mention as a unique non-lethal issue.

The most stressing period in any crisis is normally the timeframe in which the situation transitions to hostilities. In the gray area between the heightened tension and the firing of the first shot, ROE are usually very restrictive, and the availability of ROE options is highly constrained. The addition of non-lethal weapons can provide greater flexibility in the prevailing ROE but can also increase hesitation as forces in the field deal with a new dimension in the force spectrum. The following are specific ROE issues relevant to non-lethal weapons:

- Risk. Non-lethal weapons cannot create a reduction in lethal-force capability (that is, non-lethal weapons must supplement, not replace, lethal weapons).[5]
- Humanitarian. Developers of ROE must realize the potential for maiming and the lethal results of non-lethal weapons but must not forget that lethal weapons can have the same results—the difference is the expectation of lethality.
- Political. Potential unintended consequences of non-lethal weapons (maiming or killing) can result in a loss of the measured and proportionate response the commander hopes to achieve by using non-lethal weapons.
- Objective. Non-lethal weapons are most frequently associated with municipal police forces. For these forces, avoiding collateral damage (that is, the citizenry they are charged to protect) is paramount. For military forces, avoiding collateral damage is an important consideration in some scenarios, but the overriding objective in most scenarios is mission-oriented. There is a potential for the military non-lethal weapons user to inappropriately elevate the avoidance of collateral damage to a status equal or superior to the mission objective.
- Legal. Non-lethal weapons may be encumbered by international protocols. Such protocols may limit the availability and effectiveness of these less-than-lethal options.[6]

Health and Safety Issues

One of the biggest potential roadblocks to the successful acquisition and use of non-lethal weapons is the lack of clear, peer-reviewed health and safety data on the technology and target effects. Health and safety data are the keys to obtaining policy approval and public acceptance. Antimateriel and antipersonnel weapons, as well as some types of information weapons, must have data supporting their safe use and health risks.

In addition, the relative reversibility of antipersonnel non-lethal weapons must be well understood and documented. Both the immediate effects and the long-term risks to people—be they the intended or unintended targets—must be well understood and documented. To gain this understanding, the following target parameters must be thoroughly studied:

- Range and precision of delivery
- Radius of the effect
- Ability to assess the effectiveness
- Effectiveness of countermeasures or antidotes

When possible, nationally and internationally accepted safety standards should either the basis for be the utility or the acceptability of non-lethal weapons. For some types of chemical non-lethal weapons agents, such as calmative agents, U.S. Food and Drug Administration approval may be needed before they are employed. Peer-reviewed medical health and safety data documentation will be vital in countering any legal challenges that may arise immediately after non-lethal weapons are used, or even years later.

In September 1995, the Secretary of Defense established a policy banning the development of laser weapons specifically designed to blind personnel. This action was taken in response to public pressures

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[5] The Marine Corps recognized this risk and established guidelines for the use of non-lethal weapons in Somalia:
-- No Marine should be put at risk in an attempt to employ non-lethal means
-- Less lethal means should not be used in lethal situations
-- Units using less lethal means should always be covered with lethal weapons as a backup
-- Non-lethal weapons should not be used without reason

[6] LCDR Michael W. Douglass, USN, "Rules of Engagement for Non-Lethal Weapons," 18 May 1998.

exerted by the International Red Cross and the Human Rights Watch group.[7] The Swiss government requested approval of an additional protocol regarding laser weapons at the Vienna, Austria, Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects.[8] The Vienna Protocol is quite restrictive in comparison to the World Health Organization's definition of permanent blindness.

Laser non-lethal weapons that "jam vision" through glare or rapid light adaptation (that is, flashblindness) are legal by definition of the Vienna Protocol because their effects are temporary, unless the visible-wavelength laser energy on target is high enough to produce retinal laser burns. This latter point is particularly important. The relationship between wavelength, pulse width, repetition rate, and energy on target in producing ocular laser effects is complicated and highly interrelated. Lasers with wavelengths that are not typically associated with retinal damage (that is, far infrared) are commonly referred to as "eye safe." However, if the energy of these lasers is high enough, they could produce severe enough corneal damage to make them unsafe to the eyes.

Design Issues

DoDD 3000.3 states that non-lethal weapons must be "designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment."[9] All categories of non-lethal weapons must successfully fulfill three criteria to be acquired, fielded, and legally used:

- Technical feasibility
- Operational utility
- Policy acceptability

Unless all three of these criteria are met, the proposed non-lethal means will never be fielded for use by the warfighter.

A weapons developer must know the desired military objectives to determine the desired target effects and the parameters necessary to produce those effects in the right types of operational settings. From this information, weapons-design criteria can be derived and systems manufactured. The weapons-design criteria must be based on solid, empirical, scientific data that can be replicated and defended to the international scientific community. Basing weapons systems criteria on anecdotal, missing, or "unavailable" data is *unacceptable*. First, it will often build unreasonable expectations and lead to tremendous disappointments when the system does not perform as expected. Second, it will not survive the public scrutiny if it is ever challenged in the political or legal arenas.

Successful non-lethal weapons, particularly antipersonnel technologies, must have a large gap between the probability of producing the desired target effect for a given weapons application (or dose) and the probability of producing an undesired or unacceptable target effect. Figure 6-1[10] illustrates this point. The probabilities to produce the desired and undesirable target effects (for example, death or irreversible

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[7] Non-Lethal and Exotic Weapons Technology Humanitarian Issues (briefing), William M. Arkin, February, 1996; "Blinding Weapons Campaign Brochure, International Committee of the Red Cross, May 1995; "Blinding Weapons Condemned, Ban Urged," Human Rights Watch News Release, September 24, 1995; "USA—Laser Weapons Banned," Human Rights Watch News Release, 12 October 1995.

[8] Review Conference of the States Parties to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects, Vienna, Austria, 25 September–13 October 1995.

[9] DoDD 3000.3, "Policy for Non-Lethal Weapons," 9 July 1996.

[10] M.R. Murphy, "Bioeffects Testing on Non-Lethal Weapons: Merits, Metrics, and Methodologies," Jane's Non-Lethal Weapons '98 Conference, London, England, 1-2 December 1998

damage) are plotted as a function of the weapons application dose or exposure. Ideally, the slopes of these curves should be steep so that there is a clear delineation between no effect and the target effect. In addition, the separation between the placement of the two curves on the abscissa should be as large as possible. This separation represents the safety distance of the non-lethal weapons between producing the desired effect and the undesired effect. An unacceptable non-lethal weapon can have a shallow slope as well as a too-small difference between the dosage needed to produce the desired effect and undesired effects.

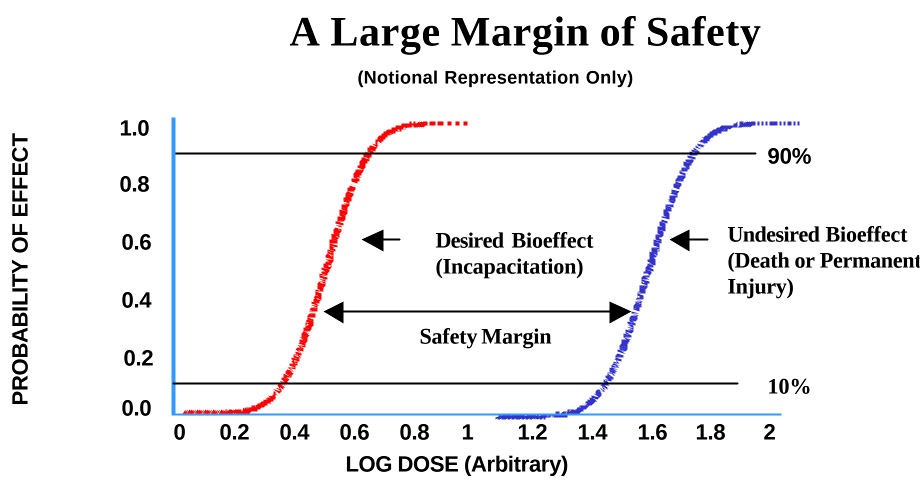

Figure 6-1. *Ideal Dose Versus Probability-of-Effects Functions for Non-Lethal Weapons Development*

Target variability can flatten the slopes of the dose response curves and shorten the separation between the desired and undesired effect functions. For antipersonnel non-lethal weapons, biological variability includes age, size, gender, general health status, genetics, and protective devices. For antimateriel non-lethal weapons, target variables include materials, electronics components, engineering design and manufacturing, and shielding. Information weapons effects can vary according to cultural, political, and motivational variables.

Normative Issues

Given that the bureaucratic and acquisition issues are successfully addressed, the new weapon system must then be accepted by the user and the public before it can be fully integrated into the standard capabilities package. Non-lethal weapons face some special challenges in this area.

Military Culture Shift. In the absence of non-lethal options, the application of military force has historically been measured in destructive power. The evolution of military thought has therefore engendered the notions that "more lethal is better" and "if it isn't lethal, why use it?" The introduction of non-lethal weapons into a commander's arsenal will challenge these age-old views. When a mission kill is as acceptable as a hard kill, non-lethal weapons may offer a cheaper alternative to lethal weapons, with less potential of collateral damage and reduced reconstruction costs after the conflict ends.

Air Force leaders must understand, embrace, and optimize the advantages offered by using non-lethal weapons capabilities available at the less-lethal end of the force continuum. Without this culture shift, the Air Force will never realize the benefits of non-lethal weapons in its operations—conventional or otherwise.

Public Acceptance. Human rights organizations[11] have been quick to condemn many of the advanced weapon and non-lethal weapons development programs as "caus[ing] unnecessary suffering, hav[ing] indiscriminate (omnidirectional) effects, hav[ing] no antidotes … and … creat[ing] enormous collateral damage." These groups further charge that "fallacious threat justification is used to support research" for these weapons. With this type of media promotion and the general public's continuing demands for reduced collateral damage and civilian causalities, the Air Force must carefully plan and select which non-lethal capabilities it develops and uses to avoid public outcries that might culminate in national policies constraining military capabilities.

Public outcry prompted by similar human rights group and International Red Cross concerns[12] have already resulted in one laser weapon program being canceled, even though it was not being designed for the uses these groups oppose.[13] The general public will likely embrace and support these anti–non-lethal weapons media campaigns if they are not otherwise informed of the immediate and long-term effects of non-lethal weapons under consideration and development by the Air Force.

All non-lethal weapons development, acquisition, and employment efforts should incorporate a carefully planned and coordinated public information release plan. Among the biggest culprits in the public's negative perception regarding non-lethal weapons are the strategies by which they have been or have not been developed and marketed. Many industrial and DoD development organizations have raised the public's expectations beyond a reasonable level by over-marketing their technology's target effects. These marketing strategies are often based on limited or anecdotal data. When the technology fails to achieve the advertised effects, support for the non-lethal weapons can backlash, even when they provide other useful capabilities. In other cases, marketing strategies have scared the public or Human Rights Groups into questioning if the lack of lethality brings a more horrific consequence or extended suffering than using lethal force.

Cultural Aspects. Recent conflicts in Grozny and Somalia have demonstrated how cultural influences can change the shape of war. Religious, ethnic, and other cultural influences can significantly influence how a population reacts to foreign military involvement or force application. Civilian populations that may be generally support the political objectives of the foreign military may strongly object to the means by which force is applied.

The level of technological maturity or religious fervor in the target society may render some types of non-lethal technologies more effective than others. For example, seeing a bright light come from an aircraft to incinerate objects or seeing the effects of an invisible "force field" repel personnel or shut down equipment may have greater impact on personnel in cultures where the technologies or their target effects are not understood. These same technologies may have little effect in cultures that are more technologically advanced and have deployed effective countermeasures. Cultural factors may also cause the population to be incited by the use of certain non-lethal technologies. The indiscriminate disruption of basic infrastructure services, for example, may be considered as a grossly unacceptable application of force against the society. This perception could incite otherwise noncombatant civilians to take up arms.

Understanding and predicting cultural influences on target effects is particularly important to information weapons. Information weapons and psychological operations will be effective only when they are tailored to the views and cultural beliefs of the society at which they are targeted.

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[11] William M. Arkin, "Non-Lethal" and Exotic Weapons Technology Humanitarian Issues (briefing), February 1996.

[12] Ibid. "Blinding Weapons Campaign Brochure," International Committee of the Red Cross, May 1995.

[13] "Blinding Weapons Condemned, Ban Urged," Human Rights Watch News Release, 24 September 1995; "USA—Laser Weapons Banned," Human Rights Watch News Release, 12 October 1995.

Research and modeling to support cultural predictions for information operations (IO) and non-lethal weapons effects are severely deficient in the Air Force, DoD, and academic communities. The Air Force must develop cultural prediction capabilities if they are to reap the full benefits of non-lethal and information weapons use in OOTCW or to successfully plan and execute an IO strategy.

6.1.2 Planning Tools

The Force Management Panel addresses the algorithm and software requirements for the development of non-lethal modules into current and programmed operational planning systems. This section will address other supporting inputs required to integrate non-lethal effects into programmed planning systems.

The integration of non-lethal effects into the state-of-the-art computer-based tools used in current Air Force and joint planning should increase the likelihood that such effects will be given appropriate consideration in a coordinated plan.

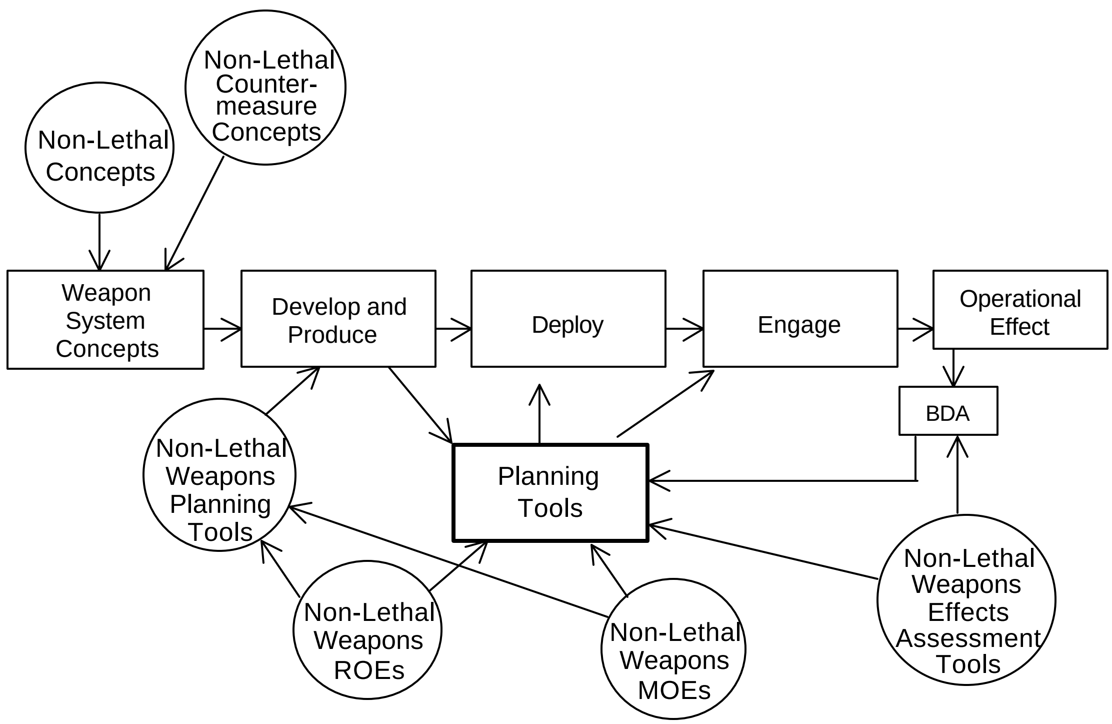

Figure 6-2. *Integration of Non-Lethal Effects Into Air Force Weapons Systems And Operations*

Considerable analysis must be completed before combat systems can be realistically incorporated into an operational planning system. Figure 6-2 depicts how the elements related to non-lethal weapons (shown here within circles), can be introduced into Air Force acquisition and operational processes. Ideally, the operational planning tools would be developed in concert with the non-lethal technology. In this way, the planning tool could be used to aid the development of the most effective non-lethal effects. Additionally, non-lethal countermeasures could be explored and preemptively addressed at the earliest stage.

Figure 6-2 shows that ROE and measures of effectiveness (MOE) should be integrated directly into the existing planning process (for example, expanding the Joint Munitions Effectiveness Manual [JMEM] to include MOE for new non-lethal weapons). Also new planning tools needed specifically to accommodate non-lethal weapons are shown entering the existing system acquisition development process then emerging to be integrated with existing planning tools. New non-lethal weapons concepts and non-lethal weapons countermeasure concepts are shown entering the front end of the system acquisition process.

Also shown are the battle damage assessment (BDA) or effects-assessment tools unique to non-lethal weapons, which must be developed and integrated with other BDA planning tools. The planning tools emphasized here are those that plan Air Force structure deployments and combat operations. The panel recommends that the offices of primary responsibility (OPRs) be assigned to ensure that tasks in the circles are performed and that their results are coordinated and integrated with the OPRs for the processes at the tips of the arrows.

In the case of non-lethal weapons, most of the analysis that is required to support integration into operational planning tools is similar to lethal weapons—weapon effects, weapon effectiveness, simulation and modeling, etc. Unlike their lethal counterparts, non-lethal weapons have two unique prerequisites—legal constraints and host-nation approval—addressed elsewhere in this document.

Lethal effects are thoroughly characterized in the JMEM series. Given a desired probability of kill (P_k) and a specific target type, the manuals provide a statistically derived estimate of the number of weapons required to achieve the entry-argument effect. Non-lethal weapons have no P_k associated with them; nor has the exhaustive experimentation upon which the JMEM series is based been conducted for non-lethal weapons. Extensive research must be conducted into the effects of non-lethal weapons, both direct and indirect, before meaningful weapon effect MOEs can be developed and a non-lethal compendium to the JMEM produced. The major challenge to developing such effects calculations for non-lethal weapons is that the needed output measure is an evaluation of functionality rather than of physical destruction. It is difficult to evaluate discrete functionality at a point in time. It may prove to be even more difficult to estimate down time and projected time to repair. Measuring functionality will be more difficult for some targets than for others. Many anti-equipment and anti-materiel effects, for example, are one-dimensional. An electrical distribution plant, for instance, is either distributing electrical power or it isn't. That physical state is relatively easy to measure. The duration of the nonfunctional condition, however, can be difficult to measure if the cause is not a readily assessable physical condition. Multidimensional functionality targets, such as personnel, will likely be significantly more difficult to evaluate.

"Weapon effects" describe the impact of a weapon on its intended target, as well as potential collateral damage. "Weapon effectiveness" is used here to describe the effectiveness of a weapon in a larger mission sense. For example, a non-lethal weapon effect might be the interruption of electrical power distribution within a given geographical area while the weapon effectiveness of a non-lethal weapon would address the impact of such an interruption on an adversary's ability to operate in a manner the U.S. planner was attempting to disrupt. This understanding of weapon effectiveness is critical to the effects-based planning calculus. Effects-based planning is gaining favor in the lethal weapons planning world and may soon become the preferred method for developing joint plans. If non-lethal weapons are to become credible, integral options available to the commander, their effects must be equally understood and readily available. As with the weapon effects discussed above, the more dimensions there are to a target and the more complex the relationship of the target to its supported system, the more difficult it will be to understand non-lethal weapons effectiveness.

Simulation and Modeling

The existing Contingency Theater Automated Planning System and the forthcoming Theater Battle Management Core Systems software-based planning tools have no provision for planning the use of non-lethal effects. In fact, the systems have no provision for any effects-based planning—lethal or non-lethal. In addition to the MOE discussed above, the underlying modeling necessary to estimate and evaluate non-lethal effects and support effects-based planning does not exist. Simulation algorithms and subsequent models will require the physics-based inputs from the weapons effects and weapons effectiveness identified above.

6.1.3 Missions and Needs for Non-Lethal Weapons

General Mission Areas

Non-lethal weapons can have a significant impact in some general mission areas. These include the following:

- Military operations in urban terrain (MOUT)
- Force protection
- IO
- Psychological operations (PSYOP)
- Suppression of enemy air defenses (SEAD)
- Humanitarian relief
- Peacekeeping

Non-lethal capabilities provide an excellent resource for MOUT because they are designed, by DoD directive, to limit collateral damage, environmental destruction, and permanent injury to personnel. Some of the most daunting challenges to MOUT involve conducting operations in a manner in which the tactical and strategic objectives can be accomplished in tightly confined areas, densely populated by combatants and civilians. To acquire maximum capabilities to conduct MOUT, the Air Force should develop and employ non-lethal capabilities that can be precisely targeted and projected through standard building materials.

Force protection, humanitarian relief, and peacekeeping operations can also benefit tremendously from the employment of the right types of non-lethal capabilities. The ROE in these missions are likely to be more restricted than in other missions in terms of using lethal force. Long-range non-lethal weapons capabilities, particularly those that can be administered from airborne platforms, can be vital in creating a barrier between friendly assets and unruly civilians or combatants. The ability to warn these groups that non-lethal means will be used if their behavior does not change will also need to be developed to support these mission tasks. PSYOP and IO can assist with these latter tasks and possibly produce a synergistic effect when used in combination with other non-lethal weapons.

Counterproliferation and counterterrorism are two other mission areas where the use of non-lethal weapons may play a vital role in achieving the objective with minimal risk to personnel. Non-lethal weapons offer needed capabilities for U.S. forces—the ability to neutralize weapons of mass destruction (WMD) without detonating them and the ability to neutralize a terrorist without risking innocent lives by using lethal weapons.

Non-lethal capabilities to disrupt enemy information systems or infrastructure can also provide significant operational capabilities for deterrence during OOTCW. These capabilities could be particularly significant during clandestine or special operations. Airborne dissemination of technologies that can emulate computer viruses or deceive the enemy into focusing on other areas of activity can significantly enhance our abilities to conduct operations.

An exciting area for non-lethal weapons is in SEAD operations. Airborne delivery of directed energy to disrupt enemy integrated air defenses and passive and active early-warning detection sensors will enable the Air Force to master the critical operational element of surprise without requiring extensive stealth technology. Non-lethal directed energy that provides aircraft self-defense by misguiding missile flight control or jamming enemy missile sensors also alleviates the need for stealth technology to operate in all environments during day and night.

Specific Documented Operational Needs

The AFSOC is the only Air Force major command that has succinctly documented the need for non-lethal capabilities in its requirements documents and Mission Area Plans (MAPs) and has begun to lay out a vision of how non-lethal weapons could be integrated with AFSOC's aircraft and operational tasks. The HQ AFSOC document, "*AFSOF 2025*," which is a culmination of their MAPs, states:

> *The greatest requirement in the area of weapons employment is the development and fielding of a class of non-lethal weapons for use by Special Operations Forces (SOF) personnel and platforms. SOF currently does not have a non-lethal weapon. Increased political interest and the potential for SOF involvement in counterproliferation and counterterrorist operations necessitate some kind of non-lethal capability.*[14]

AFSOC Joint Mission Needs Statement (JMNS) # 003-95, "Non-lethal/Limited Effects Weapon Capability," states that:

> *Although non SOF-specific requirements have not been identified (i.e., required systems which already exist or are being developed by other agencies), non-lethal/limited effects weapons capabilities are required to provide SOF with the ability to influence the action of adversaries without resorting to lethal/destructive force. They will provide an intermediate choice between doing nothing and responding with conventional weaponry. Non-lethal/disabling weapon capabilities will minimize the potential for collateral damage to personnel and equipment. Man-portable, small vehicle (wheeled, tracked, and boats) mounted, and large platform (aircraft, ship) mounted capabilities are required. Non-lethal/disabling weapon capabilities that can disable personnel (individually and in groups) and equipment and be used to neutralize or clear structures ranging from light construction to fortified bunkers are required.*

This JMNS further indicates that non-lethal weapons will support the USSOCOM's core and essential tasks of foreign internal defense, conduct coalition support operations, plan and execute humanitarian assistance, execute security assistance support, provide support to population security and civil affairs.

The AFSOC Precision Employment and Strike (PE/S) MAP portion of "*AFSOF 2025*" further explains the need to replace the 20-millimeter (mm) guns on the AC-130H gunships with a non-lethal weapons capability. A combination of advanced lethal and non-lethal weapons for the conceptual follow-on gunship to the AC-130U, called the AC-X, is also described. The PE/S MAP mentions two operational deficiencies for airborne and ground-based non-lethal weapons—the AW-114 lacks airborne non-lethal weapons, and the AW-153 has limited capability to protect high-value assets at forward locations.

The AIA has an extensive list of mission requirements and shortfalls for PSYOP.[15] Some of these needs were fundamental to the considerations of this panel.

In 1998, the Combat Air Force published a force protection Mission Needs Statement[16] that covers a variety of force protection capability needs, including non-lethal weapons. Non-lethal weapons capability needs specifically could apply to the documented improved force protection capability needs.

The Air Mobility Command also has a generic operational deficiency for force protection that includes non-lethal weapons capabilities.

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[14] *AFSOF 2025* (AFSOC's Mission Area Plans and Technology Roadmap, 1995).

[15] Air Intelligence Agency Psychological Operations Division Mission Requirements, 1 April 1999.

[16] Final Mission Need Statement (MNS), MNS Combat Air Forces 314-97, Enhanced Force Protection Capabilities, 30 June 1998.

6.1.4 Linkage to Global Engagement Operations (GEO)

The matrix in Table 6-1 shows how non-lethal weapons support the Deter, Halt, and Win phases of Air Force GEO.

Table 6-1. *Linkage of Non-Lethal Weapons Contribution to GEO*

Phase	Element	Non-lethal effects link to GEO
DETER	Focus aerospace intelligence, surveillance, and reconnaissance to conduct appropriate information operations	Exploit the strategic PSYOP campaign through advanced delivery concepts
		Enable coalition operations and deceptions with advanced PSYOP delivery concepts
	Strengthen the strategic air bridge	Contribute to the forward positioning of mobility assets with non-lethal aircraft self-protection systems
		Employ non-lethal effects to assist in area security around seaports and aerial ports of debarkation
	Respond rapidly with forward- and home- based Aerospace Expeditionary Forces and arrive early to execute the mission	Contribute increased breadth to the force spectrum available for use directly in the theater or to the quick regeneration of forces
		Enable extended range operations from theater bases by providing non-lethal effects with a smaller logistic footprint than lethal weapons
		Contribute increased breadth to the force spectrum available for the execution of joint force commander (JFC) tasks for enhanced deterrence
	Employ dynamic command and control and agile logistics	Certain non-lethal systems could have smaller logistic footprints than lethal systems, and the effective use of non-lethal weapons could reduce the requirement for lethal weapons.
HALT	Exploit information operations	Control enemy awareness and continue to shape enemy strategic perceptions with advanced PSYOP and IW delivery systems
	Employ precise and decisive aerospace power	Contribute increased breadth to the force spectrum available for effects-based targeting, to neutralize enemy offensive capabilities, disable the enemy's integrated air defense system, and protect coalition aerospace defense systems
	Master asymmetric strategies	Contribute increased breadth to the force spectrum available to disrupt enemy WMD capability
	Find, fix, track, target, and engage anything significant in near real time and assess its effects	Contribute increased breadth to the force spectrum available for more rapid and precise targeting, dynamic assessment, planning and execution, and battle management
WIN	Continue to counter adversary capabilities	Contribute increased breadth to the force spectrum available to further leverage U.S. aerospace and information superiority and employ the JFC's precision engagement capabilities
	Hold at risk strategic, operational, and tactical targets	Contribute to a more effective IW campaign with advanced delivery systems
		Provide a more appropriate level of force for response to asymmetric threats
		Provide additional options for ready precision engagement
	Enforce political, economic, and military sanctions with aerospace power	Limit the adversary's options with area non-lethal effects tuned to the situation
		Contribute increased breadth to the force spectrum available to control or isolate the desired battlespace and to the counter adversary reactions
	Integrate aerospace forces into the combined counteroffensive	Contribute increased breadth to the force spectrum available to the joint force air component commander in the conduct of theater-wide operations and the achievement of component objectives

6.2 Technologies for Non-Lethal Effects

6.2.1 Introduction

The panel studied available material that surveyed potential technologies and approaches for the application of non-lethal effects[17, 18] and visited several laboratory efforts. In addition, the panel was briefed by the Air Force Research Laboratory (AFRL), the Army non-lethal warfare activity, and the JNLWD. In the process, the panel was able to assimilate a picture of non-lethal developments on many fronts and could determine some of the technologies suitable for OOTCW.

This section provides an overview of the state of the art in those technology areas for which unclassified information was made available. Prior to delving into those technologies, it is appropriate to provide a summary of the consideration for the use of non-lethal weapons.

6.2.2 High-Power Microwave (HPM) and Electromagnetic Pulse (EMP)

Directed-energy weapons have both non-lethal and lethal applications. For example, the use of directed energy in a gunship-like application for area denial and vehicle stopping can be an effective non-lethal application of HPM technology. Further development of HPM will enable lethal effects as well, but non-lethal applications will still be useful and important. The notion of constructing an impenetrable shield around an aircraft is a compelling one since surface-to-air missiles present a formidable threat to Air Force operations. Ultimately, a directed-energy weapon that destroys incoming missiles would be preferable, but in the near term, systems that deflect missiles are acceptable. Even for non-lethal applications, new, enhanced power systems for aircraft and new HPM devices will be necessary to realize the full impact of directed-energy weapons.

Microwave effects on electronic equipment vary from target to target. For a given type of equipment, sensitivity to HPM varies with frequency. A single frequency within the lethal range can be used to destroy a target if the power is high enough, but lower power can be used if the frequency range of the microwave signal covers the entire band of sensitivity. Frequently, therefore, a broadband device will have more general applicability than a narrow band device, and power can be lower than for a narrow band device that causes equivalent damage.

Antennas for the projection of wideband signals are not widely available, but some progress has been made in this field, and antenna availability will not be a significant problem for HPM devices in the next decade. A developmental ultrawideband antenna is shown in Figure 6-3.

The development of sources is also proceeding well. A developmental source is shown in Figure 6-3. While the technology being developed is applicable for damaging targets other than missiles, the application indicated is aircraft self-protection,. Self-protection is as important an application of HPM as offensive attack. Other device aspects shown in Figure 6-3 are also important for all HPM applications. These include prime power generation, platform integration engineering, and effects on attacking missiles.

The lethality of HPM against devices will continue to be a contentious issue. The susceptibility of a device depends on fabrication methods and prior history, such as maintenance. A significant program in the simulation of effects should be established and maintained. HPM effects will be expressed in terms of a kill probability, which will depend on the serial number of the device attacked as much as on the physical effects. This uncertainty will not render HPM unusable, but its uncertainties must be understood

[17] Col John L. Barry, et al., "Non-lethal Military Means: New Leverage for a New Era," Harvard University National Security Program Policy Analysis Paper 94-01, 1994.

[18] Col Joseph Siniscalchi, "Non-Lethal Technologies: Implications for Military Strategy," Air University, March 1998.

and included in estimates of mission success. Also, damage assessment methods must be developed to determine the effect of HPM on an enemy system.

AIRCRAFT SELF-PROTECTION HPM SHIELD-ENABLING TECHNOLOGIES

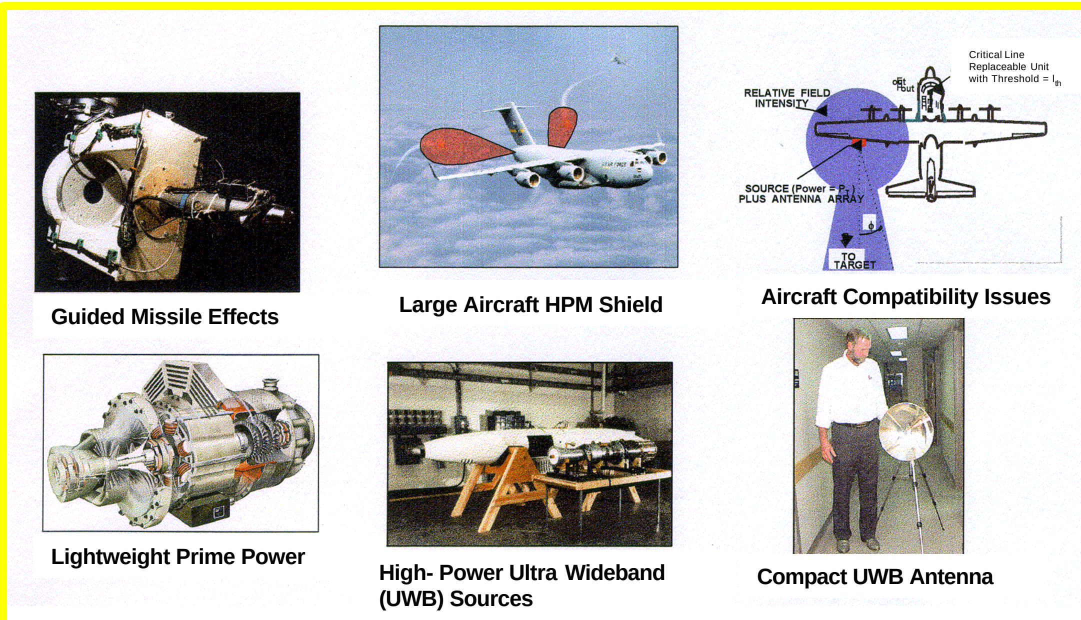

Figure 6-3. *High-Power Microwave Systems*

6.2.3 Lasers

Lasers can contribute to the continuum of lethality effects mentioned earlier in terms of their ability to intimidate, warn, scare, incapacitate, disable, and, ultimately, destroy. They can be very discriminatory because of their directionality and coherence, that is, ability to be pointed and tightly focused. On the other hand, broad area effects are difficult to achieve unless very high powers are used. Effects can generally be characterized by laser irradiance on target measured in Watts per centimeters squared (W/cm^2), dwell time of the "spot," and the characteristics of the target and its surroundings, such as reflectivity and the heat transfer environment. Humans will feel heating at 0.1 W/cm^2 and will feel discomfort and burning above this level. Metals will melt at approximately 1 kilowatt $(kW)/cm^2$, and dusty air will break down at 10^7 to 10^9 W/cm^2, depending on wavelength.

Lasers are already in widespread use within DoD for detection, ranging, and target designation. Current R&D programs within the Air Force tend to be conducted at the two ends of the power spectrum. At the low-power end, there are programs for illumination, detection, jamming and disorientation, which can occur with laser illumination of the eyes well below eye damage thresholds. As stated earlier, it is explicitly against DoD policy to use lasers to cause permanent blindness.

Air Force programs briefed to the panel were extremely conscious of this policy and are carefully designed to minimize the chances of accidental blinding. As pointed out earlier, the subject of eye damage is a complicated subject. Independent of wavelength, all lasers at a certain power level can be eye damaging. Here it is tacitly assumed that when "personnel disorientation" is referred to, all eye safety

issues have been considered and engineered into the application. Laser disruption can also be employed against artificial "vision" systems such as forward looking infrared (FLIRs) and night vision goggles.

At the other end of the spectrum are the high-power laser programs—such as the airborne laser (ABL)—designed to destroy targets at long ranges from airborne platforms. These applications, based on our earlier definition of non-lethality, would be lethal. However, depending on the power level, range, and degree to which they are focused, even high-power lasers can be used to provide for non-lethal effects. At closer ranges, high-power lasers could provide for wider area coverage of non-lethal effects.

Capabilities

It is possible to imagine the irradiances that can be achieved at various ranges and, hence, the achievable physical effects on both personnel and materiel, by considering the diffraction-spreading behavior of uniformly illuminated apertures. Such physics are an acceptable first-order approximation to the behavior of a high-power, multimode laser beam. A beam of light emanating from a uniformly illuminated aperture of diameter D will spread at a diffraction half angle of $1.22\ \lambda/D$, where λ is the wavelength of the laser light. Assuming a wavelength of 1 micrometers (μm) in the near infrared (not far from the wavelength of the chemical oxygen iodine laser, COIL) and an aperture of 1 meter (m) (a realistic size for an airborne platform), the diffraction-spreading half angle will be $1.22(10^{-6})$ radians. The focal radius of the laser spot at a range R is given by the product of the range and diffraction-spreading angle and allows calculation of the irradiance achievable on target. Here it is assumed that the range does not exceed the Rayleigh range, the range over which the beam can maintain collimation at a constant diameter. Beyond this range the laser will begin to expand and the irradiance will drop. This would be allowable for low-irradiance broad-area non-lethal effects but not for higher irradiance intercepts. The Rayleigh range for the above parameters would be about 400 kilometer (km).

Table 6-2 displays the laser irradiances achievable for various laser power levels at various ranges. This table assumes no loss in transmission over the range and no degradation of the beam quality through the atmosphere and, thus, represents highly idealized estimates. These calculations demonstrate the difficulties of achieving extremely high intensities, greater than 10^9 W/cm^2 where air breakdown and other nonlinear phenomena might lead to new non-lethal effects to be exploited, for example, artificial lightening. Given knowledge of irradiance effects on personnel and materiel, one can determine the measure of effectiveness for a given non-lethal concept employing laser means.

The laser threat and laser weapons can be used against U.S. forces as well as by U.S. forces. The Air Force is a sensor-intensive force for both weapon delivery and reconnaissance. It also depends heavily on information collection, dissemination, and use. Many of the sensors used for these purposes are based on optics and all sensors, except the human eye, use complex electronics. The optical sensors are vulnerable to laser attack. Commercially available lasers that can be effective against optical instruments and the human eye are widely available and relatively inexpensive. For example, it has been demonstrated that a low-power visible laser can disorient a pilot and destroy pilot efficiency. Thus the panel faces the possibility of having an aircraft disabled, or rendered ineffective, by one adversary using a device that costs less than $1,000. Low-power laser technology has proliferated around the world to the point that U.S. forces may eventually experience the effects of lasers HPM on sensors and personnel. It is not likely that other nations will develop HPM as a major weapon system designed to oppose U.S. forces, but the low cost and the news of U.S. developments may stimulate use by foreign powers in limited applications.

Table 6-2. *Laser Irradiances (W/cm^2) for a Laser Wavelength of 1 μm and an Aperture of 1 m for Various Laser Power Levels and Ranges*

Powers of 10 shown parenthetically

	Laser Power Level (kW)				
Range (km)	10	50	100	500	1,000
10	2.1(3)	1.1(4)	2.1(4)	1.1(5)	2.1(5)
20	5.3(2)	2.7(3)	5.3(3)	2.7(4)	5.3(4)
50	8.5(1)	4.3(2)	8.5(2)	4.3(3)	8.5(3)
100	2.1(1)	1.1(2)	2.1(2)	1.1(3)	2.1(3)
200	5.3	2.7(1)	5.3(1)	2.7(2)	5.3(2)

Technologies

Lasers are a highly mature, though still advancing, field with a very strong installed commercial base for scientific, industrial, and military applications. The United States has very high competence in the science and engineering of laser devices, the concomitant optoelectronic technologies, and the plethora of applications resident in our national laboratories, universities, and in industry. Many of our allies and adversaries have similar capabilities. Thousands of books abound in this area together with dozens of technical journals and trade publications. The intent of the this section is to summarize only the non-lethal effects information that the panel specifically studied.

Near-term non-lethal devices under development with the Directed Energy Directorate of the AFRL serve the primary non-lethal functions—to intimidate, warn, or scare. Implicit in this is also the ability to detect potential threats. The prototype SABER 203 program featured a red diode laser—essentially a laser pointer—that emitted 500 milliwatts at 670 nanometers (nm), was mounted on an M-16, and had the ability to disorient at 20 to 50 m, to designate at 20 to 30 m, and to provide some psychological deterrence. In Somalia the device was demonstrated to have psychological effects on groups trying to penetrate a perimeter. The device's mounting on an operational lethal weapon may well have contributed to this deterrence—unlike a handheld laser pointer. The engineering and manufacturing development (EMD) version features a laser that emits at 650 nm with power reduced to 28 milliwatts for enhanced eye safety. The device can also disorient, making it difficult for the enemy to conduct operations while remaining eye-safe. It is used to engage a single individual at a time and effectiveness, in all probability, is target-dependent. It is likely to be most effective against poorly trained targets. Because of its low-power eye-safe operation, it is less effective under bright daylight operations.

Another concept under development is the Battlefield Optical Surveillance System, consisting of a suite of optical sensors and lasers mounted on a high-mobility multiwheeled vehicle. Two kinds of optical sensors are on board and include a long-wavelength FLIR for thermal targets and a night vision tube for low–light level target acquisition. A near-infrared (IR) laser, 8 W at 808 nm, serves as an illuminator for the night vision tube and is quite effective in "finding" sniper scopes and other such devices. A second green laser is on board to provide a capability to disorient, delay, or deter. It features a high-efficiency frequency-doubled neodymium yttrium aluminum garnet (Nd:YAG) laser, diode pumped at 808 nm, focused into a fiber-optic cable for transmission to the output lens. Missions envisioned include the surveillance and disruption of small groups of lightly armed adversaries before potential engagement with lethal means. The sniper detection mission has been demonstrated in a recent MOUT advanced concept technology demonstrations. Laser research is also ongoing into solid-state lasers emitting nearly 2 μm in the so-called eye safe region for use as illuminators and designators. As pointed out earlier, no laser is strictly eye-safe unless its power levels at the target are very carefully controlled.

Higher power versions of the foregoing concept could certainly be packaged for airborne applications. Nd:YAG laser technology is highly developed and could be packaged to provide a disruption capability from the air and over broader areas. This would be the equivalent of an aerial laser light show. Whether this technology would have a deterrence or intimidation capability would need to be determined.

At the opposite end of the power spectrum is the advanced tactical laser (ATL) being studied by Boeing. Conceptually it features a 300 kW COIL laser installed on a V-22 or a C-130 for use at the 10- to 20-km range. The power density at these ranges is sufficient to disable or destroy a number of targets in MOOTCW and/or in the urban warfare environment, such as power lines, transformers, telephone lines, vehicle fuel tanks, vehicle tires, tank farms, and boats. It could also discriminate well in antiterrorist scenarios. This concept is also under consideration for cruise missile defense. The proposed COIL laser, which is in subscale engineering development, offers several new engineering advances over the COIL system in the current ABL. Since it is mounted on a moving aircraft, thermal blooming of the laser beam would be minimized. For defensive intercepts, it contains 40 seconds of laser "fuel" sufficient for 8 kills from a 20-km range. It features a new sealed exhaust mode, which permits low-altitude operation. It also uses a diluent of two molecules of nitrogen eliminating the need for helium, which has been traditionally employed. Laser efficiencies in the 20 to 30 percent range have been demonstrated.

Chemical lasers of all kinds are ultimately limited on a given mission by the amount of laser fuel that can be carried. The LITE (Laser Integration Technology) program in the Directed Energy Directorate of AFRL aims to leverage technical advances in the optical fiber and fiber laser area from the telecommunications industry, integrated circuits from the electronics industry, and diode lasers used in telecommunications to develop high power, that is, approximately 100 W, high-efficiency and 30 to 40 percent wallplug efficiency, high-power density, all solid-state lasers. Monolithic building blocks on the order of a kilowatt are envisioned, as is scaling the building blocks to directed-energy weapon levels. Such lasers would have power requirements but would not require "fuel", thus providing the warfighter and peacekeeper with limitless ammunition. Together with some of the exciting developments occurring in aircraft electrical power generation in the Propulsion Directorate, this would truly enable the fotofighter of the future. Since no fuel is required, such devices could also be considered for applications from space-based assets. Mid-infrared semiconductor lasers are also being developed as infrared countermeasures to jam and disrupt IR-seeking missile threats.

Horizon

The state-of-the-art for low-power, solid-state lasers in the visible and infrared for illumination, disorientation, and jamming is sufficiently advanced to permit fielding of such systems in the near term if desired. Such devices have already been demonstrated in field prototypes for use by ground security forces. The technology exists to extend these to higher power levels for airborne application from larger distances, for example, on the order of kilometers.

Beyond 5 years, higher-power applications could emerge depending on the laser's capability on non-lethal missions. Many different types of lasers are commercially available and many have flown in airborne and space platforms, with some engineering modification, for instrumentation in science missions. High-power applications, such as those that could be provided by the ATL, are certainly feasible with further engineering developments of the chemical laser. Other factors, such as pointing and tracking of the laser on the target, particularly if moving and evading, need to be successfully solved for practical application in the field. Very high-power applications would be in the province of the ABL.

Looking beyond 10 years to continued developments in all solid-state laser systems and on-board electrical power generation, one could envision stacked, modular systems beginning to displace chemical systems at the lower power end of the high-power spectrum, that is, in the 10^1 to 10^2 kW range. Such electric solid-state systems would have a limitless "ammunition" supply, would be rugged, would require

little maintenance, and would have long lifetimes. For very high-power applications, chemical lasers would probably still be required.

6.2.4 Information Warfare (Offensive Counterinformation)

There is no doubt that the importance of both defensive and offensive IO has been the single greatest advancement in warfare in the last decade. IO are very broad in spectrum, very deep in levels of employment, and very diverse in technology needs. Figure 6-1 depicts the spectrum of IO.

Information superiority is the degree of dominance that allows friendly forces the ability to collect, control, exploit, and defend information without effective opposition. It is a core competency for the Air Force upon which other core competencies rely. In this information age, information-based technologies and information systems will remain the primary area where the pace and extent of change is greatest. While information superiority is not solely the Air Force's domain, the strategic perspective and global experience gained from operating in the aerospace continuum make the Air Force uniquely prepared to gain and use information superiority through robust IO and to execute its two major aspects: information-in-warfare and IW, and a critical portion of Air Force global engagement.

Information superiority is a force enabler in all offensive and defensive Air Force missions. Without information superiority, the ability to target, assess damage, plan missions, and defend U.S. forces will be severely degraded, if not totally absent.

The study panel investigated the area in a cursory manner. Nevertheless, the panel was struck by the degree to which the Air Force depends on information, and the degree to which the Air Force is vulnerable to (and currently experiencing) information attack. The panel concentrated on what is depicted as offensive counterinformation in Figure 6-4. As discussed elsewhere in this volume, the Scientific Advisory Board (SAB) was not able to fully assess the relationship between offensive and defensive information operations. The Air Force should ensure that it is functionally integrated to accomplish the goal of IO.

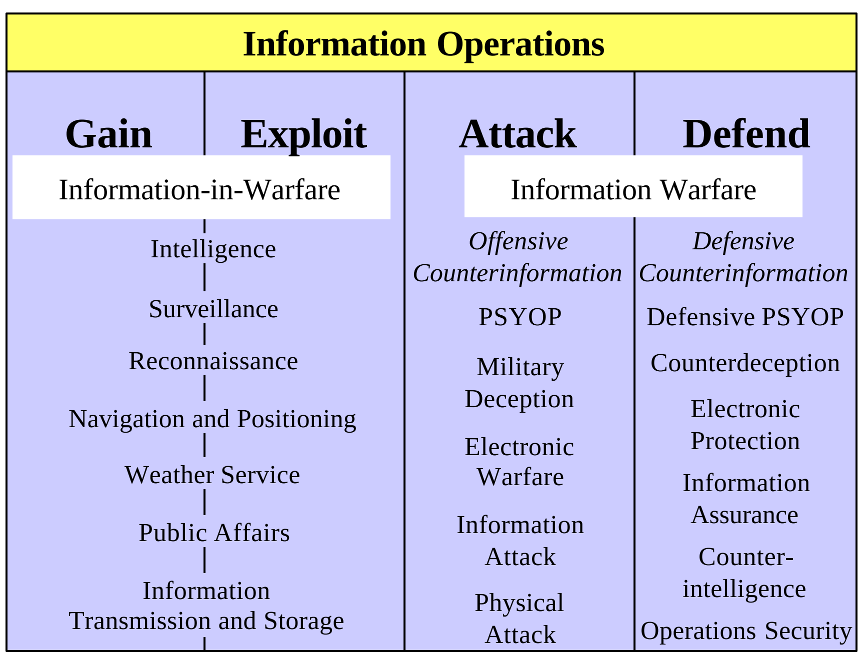

Figure 6-4. *Components of Information Operations*

Military Deception and Counterdeception

Military deception has been practiced throughout history and remains an important element of warfare. Deception is based on misleading facts, whereas PSYOP is based on using the truth as a weapon. The panel has learned that "All warfare is based on deception"[19] and that effective deception can turn the war.

The AIA (Air Force Information Warfare Agency) has a program in tactical deception and counterdeception in which it develops concepts and strategies. A Joint Instruction[20] provides general guidance in the area. The panel found deception and counterdeception techniques to be critically important to OOTCW.

Electronic Warfare

The electronic warfare capabilities of the Air Force have been severely reduced by the retirement of the EF-111 aircraft, resulting in total reliance on jamming pods and on the Navy and Marine EA-6B jamming aircraft for the screen jamming of air defense radars on air attacks. Moreover, the move of the electronic warfare organization under the IO umbrella results in a loss of the true integration of electronic warfare planning and operation into the combat air attack operations.

The EC-130 Compass Call aircraft have sole capability for airborne jamming of communications links.

The AFRL program in self-protection jamming was reviewed recently by SAB as part of the science and technology review process. It was recommended that that program be strengthened to assign more resources to the protection of fighter and bomber aircraft (it is currently focused on airlift aircraft). The panel is not aware of any program that develops new capabilities for area jamming.

Information Attack

The techniques, systems, and concepts for the attack of information systems depend on surprise, and hence the closest possible security measures must be employed. This study did not penetrate those security restrictions, and therefore, this report will not comment on technologies that may or may not be in being. In an era in which information flows are so critical to successful commercial, political, and military operations, it is essential that the Air Force consider air- and space-delivered attacks on such information systems and develop capabilities for employment.

The panel reviewed the Electronic Systems Center program to develop planning tools for IW and was provided a demonstration of the tools. The panel was impressed at the level to which the tools have been developed. The panel recommends continuation of that work, and the attendant development of BDA techniques that can determine the effectiveness of information attacks, therefore closing the loop back to dynamic replanning systems within the Air Operations Center and Joint Operations Center.

Physical Attack

Physical attack on information nodes is primarily through lethal warfare, and that is being addressed as a separate subject. It is true, however, that extremely useful weapons against such systems are HPM directed-energy systems that could disrupt and, perhaps, destroy communications nodes, particularly those employing solid-state switches and processing equipment. The panel is very excited about the potential of such weapons systems, and their role should be pursued by the Air Force.

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[19] Sun Tzu, "The Art of War," c. 500 BC.

[20] Deception Operations, Chairman of the Joint Chiefs of Staff Instruction 3211.01A.

Doctrine and Concepts

The joint doctrine[21] and Air Force doctrine[22] for IO provide very generalized descriptions and guidance that place some general bounds on IO but lack the benefit of either a bold vision or innovative thinking. Presumably this is left to the implementers, but the panel saw no additional documents that expand on the topic.

The panel recommends that, in recognition of the significant leverage that offensive counterinformation provides, the Air Force conduct an aggressive search for advanced IW concepts and the R&D community place top priority on supporting these concepts with appropriate technology development and systems acquisition.

6.2.5 Psychological Operations

Introduction

PSYOP have been used successfully in one form or another for centuries. Technically part of IO, PSYOP deal with presenting information in such a way that the audience is swayed to a particular thinking and action. PSYOP is a powerful tool available to military commanders but not taken full advantage of by leaders in today's operating environment.

It is important to differentiate between PSYOP and other military means at a commander's disposal in prevailing in-conflict operations:

Psychological Operations: Planned operations to convey selected (truth) information and indicators to foreign audiences to influence their emotions, motives, objective reasoning, and ultimately the behavior of foreign governments, organizations, groups, and individuals. The purpose of psychological operations is to induce or reinforce foreign attitudes and behavior favorable to the originator's objectives.[23, 24,]

Public Affairs: Provides objective reporting, without intent to propagandize. As open sources to foreign countries and the United States, public affairs channels can be used to disseminate international information.[25]

Tactical Deception: Actions executed to deliberately mislead adversary military decision makers regarding friendly military capabilities, intentions, and operations, thereby causing the adversary to take specific actions (or inactions) that will contribute to the accomplishment of the friendly mission.[26]

Counterdeception: Efforts to negate, neutralize, diminish the effects of, or gain advantage from, a foreign deception operation. Counterdeception does not include the intelligence function of identifying foreign deception operations.[27]

These four means at a military commander's disposal can be very important to conflict resolution, particularly in the prehostility phase. Of these activities, public affairs is clearly outside the panel's

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21 Joint Doctrine for Information Operations, Joint Pub 3-13, 9 October 1998.

22 Information Operations, Air Force Doctrine Document 2–5, 5 August 1998.

23 Doctrine for Joint Psychological Operations, Joint Pub 3-53, 10 July 1996.

24 Department of Defense Dictionary of Military and Associated Terms, Joint Pub 1-02, 23 March 1994, as amended through 7 December 1998.

25 Doctrine for Joint Psychological Operations, Joint Pub 3-53, 10 July 1996.

26 Ibid.

27 Department of Defense Dictionary of Military and Associated Terms, Joint Pub 1-02, 23 March 1994, as amended through 7 December 1998.

charter, but the remaining three have been investigated to varying degrees. This section focuses on the PSYOP mission. The key in all these activities is to *induce or reinforce foreign attitudes and behavior favorable to the originator's objectives.* There are many ways to accomplish such an objective—from media propaganda to the use of high-explosive weapons to introduce fear. The use of PSYOP in conflict resolution by Air Force commanders is rare, but this is also true of the other Services.

Capabilities

The panel reviewed PSYOP in the Air Force, primarily in the context of joint operations. The AIA is responsible for the mission in the Air Force and is building that capability as resources become available. Although far from robust, the staff capability at AIA has some ambitious plans for making the PSYOP mission more relevant to Air Force commanders. AIA's PSYOP staff position is that the Air Force is not yet into PSYOP and its use in planning and execution of operations is far from optimal.

The Pennsylvania Air National Guard operates five EC-130E Commando Solo aircraft equipped with high-power radio and television transmitter systems for the transmission of PSYOP broadcast material. This is an AFSOC-gained unit, and AFSOC also possesses MC-130 Combat Talon aircraft, which can be used for dropping PSYOP leaflets and BLU-82 bombs. However, any C-130 is capable of dropping leaflets. Some fighter aircraft are also capable of delivering leaflets using a pylon-mounted, M129 leaflet dispenser. The panel concluded that PSYOP is basically conducted in the same manner that it has been for decades. The Air Force PSYOP delivery capability, EC-130s, is a limited asset with high operational tempo (OPTEMPO), particularly for an Air National Guard unit. Also, technology has not been leveraged in modernizing aircraft that would significantly enhance the effectiveness of PSYOP.

AFSOC's MAP for Information Operations[28] lays out the Air Force's vision to enhance its role in PSYOP using a more capable, commercial-variant large-bodied aircraft, such as a 767, to replace the EC-130E aircraft. This conceptual aircraft, called the EC-X, would allow for enhanced capabilities, such as producing and disseminating PSYOP materials on board, providing a platform for high-powered, multispectral broadcasts, and possibly serving as a "mother ship" for launching or recovering PSYOP and IO unmanned aerial vehicle (UAV) platforms.

Using a commercial variant aircraft would reduce maintenance costs and contractor logistics support at a large number of commercial and military locations across the globe. A draft mission needs statement for the EC-X is in the coordination cycle at AFSOC Headquarters. AFSOC's long-range vision is to begin phasing in the EC-X aircraft in fiscal year 2007.[29] However, congressionally mandated efforts to procure EC-130J aircraft and cross-deck them for the EC-130E Commando Solo mission may thwart or erase AFSOC's plans for the EC-X aircraft.

An Air Force Chief of Staff- (AF/CC-) directed Analysis of Alternatives (AOA) has been contracted by AFSOC to determine the best approach in replacing the present EC-130E Commando Solo aircraft. The Air Force should evaluate the present program whereby the out-dated Commando Solo PSYOP mission broadcast equipment is removed from the Pennsylvania Air National Guard EC-130Es and re-installed in new C-130J aircraft. Efforts to cross-deck the EC-130E equipment to new C-130Js should be suspended until the AOA is complete and the results are reviewed. Many questions will remain unanswered until the AOA is complete. Some of these questions concern the inadequate electrical power of the C-130J aircraft, serious issues about a fly-by-wire EC-130 aircraft that radiates large amounts of energy (which may adversely affect flight safety), and weight and balance problems.

[28] See *AFSOF 2025,* Headquarters AFSOC Publication, 1995.

[29] Ibid.

UAVs could be operated from safe havens, even from the United States, with satellite datalinks for air vehicle control and transfer of mission media, capitalizing on closer ranges, reducing the required transmitter power (and hence equipment weight) significantly. Serious consideration should be given to developing high-altitude endurance UAV PSYOP equipment payloads for UAVs. Not only could stress on airframes and aircrews be alleviated (reduced OPTEMPO), but the capability for stateside operation would reduce a U.S. foreign footprint, which the expanded use of PSYOP requires.

An example of how PSYOP has contributed to mission success is in Desert Storm, where both warring sides used their capabilities, albeit with mixed success. The Iraqi efforts were directed against U.S. soldiers (a Tokyo Rose–type operation), the people of the United States (through videos of damage and interviews of captured pilots), and other Arab nations (via Iraqi News Agency broadcasts). The Iraqi efforts were minimally effective, due in part to the lack of credibility of their propaganda. On the U.S. coalition side, results were reported[30] to be quite effective. Twenty-nine million leaflets were dropped in theater, radio broadcasting coverage was maintained 17 hours per day, and audio broadcasting was maintained 19.5 hours per day. Some of the leaflets forewarned the Iraqi troops of the use of tremendous explosives by the coalition forces the following day by AFSOC MC-130s, dropping 15,000-lb BLU-82 bombs. Through these efforts, 73,000 Iraqis were affected by PSYOP, and 70 percent of the enemy prisoners of war reported that the PSYOP messages had an impact on their surrender.

In the panel's opinion, PSYOP have not been considered an important element of U.S. military strategy by military leaders. For example, the operations in Kosovo would have been an ideal opportunity to use extensive PSYOP to counter the rhetoric of the current regime, to influence or dissuade the adversarial forces, to encourage and guide the people, and to generally inform the factions. Although the lessons of the operation are not yet apparent, there is little evidence that PSYOP have been effectively used. The likelihood that there will be a shift from major regional conflict to multiple smaller-scale contingencies suggests a range of adversaries and sympathizers whose attitudes and perceptions might be greatly influenced by carefully crafted PSYOP.

Technologies

Multimedia information techniques, computers, compact transmitters, low-cost expendable air-droppable radio and TV receivers, the Internet, and small video cameras can be used to deliver such information as political messages, taped interviews of opposition leaders, bomb damage assessment, and real-time video from the nose of a weapon approaching a target. Directed-energy technologies (Buzz and Hello)[31] offer exciting applications for PSYOP, some of which have already been demonstrated on EC-130 aircraft. PSYOP systems could be used for humanitarian relief (where to find food, shelter, medical attention, what areas to avoid, etc.); domestic violence and crowd control (warnings, directions, etc.); and disaster relief (evacuation routes, where to find food, shelter, medical attention, etc.).

The panel feels PSYOP could play a much more significant role in future OOTCW if PSYOP could have the attention it deserves at the Air Force and joint level. A truly integrated, effective joint PSYOP capability that also includes the Air Force is needed. The problem and the solutions are not confined to the Air Force, but the Air Force could influence the Joint Staff to expand the thinking to consider PSYOP as a major tool in OOTCW.

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[30] "Post Operational Analysis: Iraqi Psychological Operations During DESERT SHIELD/STORM," USSOCOM, 1992.

[31] See the classified version of the Directed-Energy Applications for Tactical Airborne Combat Study Phase I report, March 1999.

6.2.6 Other Non-Lethal Weapons and Technologies

A broad range of other non-lethal weapons and technologies are either available from or are under development by a number of military and law enforcement agencies—primarily the DoD JNLWD, and the National Institute of Justice (NIJ). Nonetheless, these other non-lethal weapons have potentially broad application to Air Force missions ranging from force protection to antimateriel attack. The technical and operational employment challenges are equally broad.

Introduction

The Non-Lethal Effects Panel received focused briefings covering many non-lethal weapons techniques and technologies that did not fit into clear categories, such as PSYOP, IW, lasers, and radio frequency (RF) weapons and technologies. These other non-lethal weapons include a number of viable options that can give the Air Force a range of offensive or defensive alternatives to lethal response. At one extreme are relatively benign approaches, such as battlefield obscurants and at the other are highly aggressive approaches that are almost lethal in nature. Table 6-3 summarizes the non-lethal weapons in this category and attempts to show their fit relative to the lethality continuum. Readers requiring additional information on the specific non-lethal weapons or technologies shown should refer to Douglass, "Rules of Engagement for Non-Lethal Weapons,"[32] or Sinischalchi, "Non-Lethal Technologies Implications for Military Strategy."[33]

Capabilities

For purposes of this discussion, "other" non-lethal weapons and their enabling technologies are grouped by application (antipersonnel, antivehicular, and antimaterial) and delivery mechanism (air and non-aerial deliverable). Current capabilities in these areas primarily depend on Air Force application of other Service- and agency-developed systems.

Applications. Many other non-lethal weapons have their genesis in law enforcement and were originally developed to deal with unruly crowds where application of lethal force was not a preferred option. The initial focus, therefore, was primarily against personnel. As requirements evolved, other non-lethal weapons applications were extended to cover fleeing felons, and antivehicular systems developed. Some of the systems had inherent capabilities against material that can be enhanced by application of aggressive agent technologies under development by DoD.

- **Antipersonnel.** This category includes non-lethal weapons and technologies that target specific human physical and mental processes to achieve their intended objectives. Some employ physical constraint mechanisms that have antivehicular or antimateriel applications. The Air Force depends primarily on systems and technologies developed by other Services and agencies (for example, JNLWD and NIJ) to satisfy antipersonnel requirements in this application area.
- **Antivehicular.** Antivehicular non-lethal weapons are defined as a separate category to address the unique challenges of non-lethally halting or impeding moving vehicles. Other Services and agencies are also leading the technology developments in this application area. This category includes non-lethal airfield operation denial. No airfield-focused non-lethal weapons system and technology development appears to be underway by DoD or the U.S. Government although some antiroad vehicle approaches may be applicable.
- **Antimateriel.** These non-lethal weapons have application to a range of material targets. Non-lethal weapons in this category either exploit specific material or design vulnerabilities (for

[32] LCDR Michael W. Douglass, "Rules of Engagement for Non-Lethal Weapons," Naval War College, 18 May 1998.

[33] Col Joseph Sinischalchi, "Non-Lethal Technologies: Implications for Military Strategy," Air University, Center for Strategy and Technology, Occasional Paper No. 3, March 1998.

example, precision machined surfaces or organic materials) or try to disable the entire system. Current non-lethal Air Force anti-materiel capability development is focused on electronic and electrical equipment. No Air Force capability is under development for other materiel type targets. The Air Force, therefore, will have no option but to apply lethal force for attacking non-electrical and electronic materiel targets. An air-deliverable non-lethal weapons development initiative will be required to fill this Air Force capability gap.

Table 6-3. *Other Non-Lethal Weapons—Capability Continuum Fit*

	Type	Aerial Delivery	Delivery Mechanism	Delivery Range
	•Antipersonnel			
	•Information Operations			
Increasing Lethality	•Calmatives	yes	Spray, Munition	C, C-SO
	•Acoustic Wave	no	Beam	C
	•Optical Disorientation	yes	Flash	VC
	•Obscurants	yes	Spray, Munition	C, C-SO
	•Flash-Bang	yes	Munition	C-SO
	•Super Lubricants	yes	Spray, Munition	C, C-SO
	•Irritants	yes	Spray, Munition	C, C-SO
	•Nets	yes	Munition	C
	•Sticky Foams	yes	Squirt, Munition	VC, C-SO
	•Stun Devices	no	Projectile	VC
	•Blunt Impact Rounds	no	Projectile	VC
	•Lethal Force			
	•Antivehicular			
Incr. Leth.	***•RF Stopper***			
	•Barriers	yes	Air Drop	C
	•Super Lubricants	yes	Squirt, Munition	VC, C-SO
	•Nets	yes	Munition	C
	•Sticky Foam	yes	Squirt, Munition	VC, C-SO
	•Lethal Force			
	•Antimaterial			
	•Information Warfare			
Incr. Leth.	•Optical Coatings	yes	Spray, Munition	C, C-SO
	•Sticky Foams	yes	Squirt, Munition	VC, C-SO
	•POL Contaminants	yes	Spray, Munition	C, C-SO
	•Embrittlement Agents	yes	Squirt, Munition	VC, C-SO
	•Conductive Particles	yes	Munition	C-SO
	•Depolymerizing Agents	yes	Squirt, Munition	VC, C-SO
	•Supercaustics	yes	Squirt, Munition	VC, C-SO
	•Lethal Munition			

VC: Very Close
C: Close
SO: Standoff

Delivery Mechanisms. Most other non-lethal weapons concepts were originally intended for close-in applications, not aerial delivery. Nonetheless, other non-lethal weapons bring important capabilities for Air Force operations ranging from crew and equipment protection during humanitarian operations to aggressive operations against mechanized equipment. Table 6-4 shows that some of the approaches are compatible with aerial delivery, especially when delivered by precision-guided munitions (PGM). Some projected aerial delivery requirements are compatible with current capabilities while others will require additional development.

Table 6-4. *Aerial Delivery Mechanisms*

Type	Range	Delivery Platform	Issue
Aerial Squirt	Very Close	Helicopter	Platform Risk
Aerial Spray	Close	Transport	Platform Risk
Projectile	Close	Various	Lethality/Fusing
Unguided Bomb	Close	Fighter/Attack/Bomber	Lethality/Circular Error Probable (CEP) Required
Guided Bomb	Medium	Fighter/Attack/Bomber	Lethality/CEP Required
Glide Bomb	Medium	Fighter/Attack/Bomber	Lethality/CEP Required
Powered Munition	Medium-Long	Fighter/Attack/Bomber	Lethality/CEP Required
Standoff Weapon	Long	Fighter/Attack/Bomber	Lethality/CEP Required

- **Spray.** The traditional aerial application of atomized liquid or fine particles over large areas. Non-lethal weapons unique spray systems should not be required.
- **Squirt.** The nontraditional delivery of a liquid stream to confine the applied material to a precise area. This delivery technique is not suitable for high-speed aircraft. It is suitable for low-speed helicopter air operations and for air vehicle and security personnel use during ground operations. Handheld delivery systems are available as commercial-off-the-shelf (COTS) or government off-the-shelf (GOTS). Air vehicle mounted and aerial delivery systems may require additional development.
- **Air Drop.** The traditional aerial delivery of large payloads. Existing precision Air Force air drop techniques are probably applicable to aerial delivery of large non-lethal weapons such as vehicle and runway barriers.
- **Projectile.** Air or ground gun- or tube-fired projectile to deliver or achieve non-lethal weapons effect. COTS and GOTS projectiles in the DoD inventory and are suitable for Air Force personal-issue non-lethal weapons applications. Additional developments are under way to further enhance non-lethal weapons projectiles.[34] No non-lethal projectiles are being developed for high-muzzle velocity guns such as those installed on Air Force aircraft.
- **Munitions.** Precision-delivered unitary or cluster weapons. Non-lethal weapons munitions may not be based on current delivery systems because of the potential lethality of traditional munition cases and dispensers. Non-lethal weapons applications probably will require very high-accuracy delivery to achieve the desired effectiveness. Some guided munitions specific to non-lethal weapons are under development.[35]

Delivery Range. By virtue of their original application as alternatives to lethal force in close-in encounters, other non-lethal weapons tend to have limited effective ranges. Most are employed at very close range (tens of feet) while some can be employed at less-stringent but still close (hundreds of feet) ranges. It is only when other non-lethal weapons are delivered by munitions that effective ranges become compatible with traditional concepts of aerial delivery. Most non-lethal weapons munitions, however, must be delivered with very high precision (including aspect) in order to be effective against their intended targets. It is the requirement for either close-in or precision standoff delivery that makes aerial employment an issue for this category of non-lethal weapons.

[34] Overhead Chemical Agent Dispersal System, *1998 A Year of Progress*, Joint Non-Lethal Weapons Program, February 1999, page 13.

[35] Non-Lethal Weapons-Guided Projectile, 1998 A Year of Progress, Joint Non-Lethal Weapons Program, February 1999, page 13.

Technologies

A number of critical challenges and issues are associated with technology development for other non-lethal weapons (see Table 6-5). These challenges have been and will continue to be led and addressed by other Services, agencies, or joint organizations. The Air Force, however, has an important role to play in adapting these other non-lethal weapon and technology developments to meet the Air Force's unique requirements. It is generally recognized that the Air Force has the core competencies to support joint non-lethal weapons development. The panel, however, also believes that the Air Force has key competencies that suggest it should lead technology development in select non-lethal weapons capability gap areas.

Antipersonnel. DoD sister Services (primarily the Army and the Marine Corps), JNLWD, and NIJ have taken the lead role in other antipersonnel non-lethal weapons technology development.

Antivehicular. DoD sister Services and the NIJ have taken the lead role in this technology development area also. The vehicles of interest to these organizations, however, are primarily motor vehicles. There do not appear to be programs that address requirements for stopping or impeding armor and mechanized military equipment. Some of the other non-lethal weapons technologies developed for antimaterial applications may be applicable to such heavy vehicles.

Antimateriel. This class of other non-lethal weapons applications may prove to be the most fruitful area for Air Force–led technology development. The Air Force has a number of weapons systems capable of non-lethal attack of adversary electronic or electrical targets under development or consideration. There appears, however, to be no comparable non-lethal weapons effort against non-electrical and electronic equipment. Air Force operational and technology communities have unique capabilities in many of the areas required to enable technology development and operational employment of such weapons systems, including expertise in high-accuracy munitions delivery systems.

The AFRL Material Directorate scientists also have developed capabilities in fundamental chemical and material processes that will be required for development of fast-acting, persistent, antimateriel agents. According to briefing materials made available to the panel, depolymerizing, embrittlement, and supercaustic agents have potential antimateriel applications. One initiative with an antimechanical, antistructural material focus (briefed by Sandia National Laboratories) was a relatively straightforward application of sticky foams to slow or disable artillery pieces and gun crews.

In another initiative, the AFRL Munitions Directorate was investigating the use of chemical agents and glues for antimateriel application. AFRL also included supercaustic, depolymerizing and embrittlement technology in its presentations, but no non-lethal weapons system focus was evident. The panel concluded, therefore, that while the elements of a credible antimateriel, non-lethal weapons technology program potentially exist within the Air Force and its sister organizations, the Services are not focused on creating a viable, air-deliverable antimateriel capability within the foreseeable future.

Table 6-5. *Issues Related to Other Non-Lethal Technologies*

Type	Usage Issue
Non-Air Deliverable	
Acoustic Wave	Feasibility
Stun Devices	Range
Blunt Impact Projectiles	Lethality
Air Deliverable	
Optical Disorientation	Effectiveness
Calmatives	Dosage/Persistence
Obscurants	Persistence
Flash-Bang	
Super Lubricants	Persistence
Irritants	
Barriers	Persistence
Nets	Delivery Geometry
Sticky Foams	Toxicity
Optical Coatings	Persistence
Petroleum, Oils, and Lubricants (POL) Contaminants	Target Access
Embrittlement Agents	Response Time/Toxicity
Conductive Particles	Persistence
Depolymerizing Agents	Response Time/Toxicity
Supercaustics	Response Time/Toxicity

Recommendations

The Air Force should continue to be an active participant in joint-service and -agency developments associated with other non-lethal weapons. In particular, AFRL/Human Effects Directorate should continue to support joint development in key human effects competency areas. With the exception of antiarmor and mechanized vehicle, airfield denial, and antimateriel non-lethal weapons as noted below, the panel sees no need for the Air Force to assume the leadership role in the development of basic technologies. The Air Force, however, does need to allocate resources to adapt appropriate other non-lethal weapon and technology developments to meet Air Force–unique requirements. The panel encourages the Air Force to be more aggressive in leveraging and applying joint and other Service and agency developments to meet Air Force–unique mission requirements.

6.3 Solution Concepts

6.3.1 Delivery Concepts

In an era of reduced budgets, and an environment unlikely to support new aircraft, the study must focus on leveraging those aircraft in the inventory, with appropriate modifications—kept simple—to provide the capability to deliver non-lethal effects. The panel thus reviewed the aircraft likely to be suitable, with the goal of identifying the best candidates for delivery approaches. Table 6-6 depicts the result.

Table 6-6. *Aircraft Weapons Delivery Capabilities*

Aircraft	***Target Acquisition/Navigation***	***Integrated Global Positioning System (GPS)***	***Datalink***	***Weapon Delivery***	***Delivery Accuracy (ft CEP)***
A-10	Night Vision Imaging Systems, Low Altitude Safety and Targeting Enhancement, Pave Penny, Inertial Navigation System (INS)	No	Yes*	30-mm gun bombs, rockets, missiles, PGM, cluster bomb units (CBU), jammer pods	‡
B-1	Automatic terrain following radar and inertial navigation equipment.	Yes (Block D)	Yes†	Bombs, PGM, CBU	‡
B-2	Synthetic Aperture Radar (SAR), INS, GPS	Yes	Yes†	Bombs, PGM, CBU	‡
B-52	FLIR, Electro Optical Viewing System	Yes	Yes†	Bombs, PGM, CBU	‡
F-15 C/D	Pulse-Doppler radar or APG-70 SAR, Moving-Target Indicator (MTI) radar	No	Yes*	M-61A1 20-mm cannon Air-to-air missiles	‡
F-15E	Electro-Optical (EO)/IR, Low Altitude Navigation and Targeting, Infrared for Night Operations (LANTIRN)	Yes	No	M-61A1 20-mm cannon Bombs, rockets, missiles, PGM, CBU, jammer pods Chaff/flare dispenser	‡
F-16 C/D	LANTIRN	Yes*	Yes*	M-61A1 20-mm cannon Missiles, bombs, PGM, CBU, electronic countermeasure pods	‡
F-117	EO/IR Ring laser gyro	Yes† (RNIP+)	No	Bombs , PGM, CBU	‡
AC-130H	EO/vis sensors APQ-150 BTR, Integrated Defense System (IDS) Low Light Level Television/ Gated Laser Illuminator	Yes†	Yes†	ALE 40 flare Chaff dispensers (10 in) 40-mm gun 105-mm gun	‡
AC-130U	EO/vis sensors SAR, MTI radar FLIR, All Light Level Television/ Laser Illuminator, IDS	Yes†	Yes†	ALE 40 flares Chaff dispensers (12 in) 25-mm gun 40-mm gun 105-mm gun	‡
CV-22†	Terrain Following/Terrain Avoidance (TF/TA), multimode radar FLIR, Inertial Navigation Unit (INU), Personnel Locator System (PLS)	Yes	Yes	ALE 47 flare Gun to be determined, approximately 25 mm	‡
MH-53H	TF/TA, multimode radar FLIR, Doppler navigation system, INU, PLS	Yes	Yes*	ALE 40 flare .50-cal machine gun 7.62-mm minigun	‡
MC-130H	TF/TA multimode radar, INS, Doppler, GPS, IDS Automatic Computed Air Release Point System, Container Release System, Ground-to-Air Responder/Interrogator, High-Speed Low-Level Aerial Delivery System	Yes†	Yes†	ALE 40 flares BLU-82	‡
Unmanned Combat Air Vehicle†	EO/IR/SAR	Yes	Yes	Bombs, PGM, CBU	‡

* Partial Fleet † Future ‡ Use of GPS can provide accuracies in tens of meters; precision GPS and Differential GPS can provide single-digit accuracies.

The panel made no attempt to assess the fire-control system hardware and software for suitability. It should also be recognized that the delivery accuracies are highly dependent on the projectile or bomb, and that Differential GPS–guided canisters can be delivered with very high accuracy if the aircraft and weapon are so equipped.

The next step in our process was to relate the technologies to particular delivery modes that could be associated with the aircraft delivery capabilities. In this step, the panel concentrated on the less expensive approaches (that is, those that are compatible with the munitions release systems).

At the same time, it seemed appropriate to make an assessment of the timeframe in which the particular technology, packaged as a useable weapon, could complete its operational demonstration period and thus be ready for EMD.

It is the panel's belief that the technologies shown can be packaged for the specified delivery; however, in view of limitations regarding the status of development, further investigation is necessary. The Air Force should task the technology experts to consider the recommended delivery concepts and to verify that the packaging and the time schedules are possible, as well as to develop appropriate program plans.

6.3.2 Analysis of Technologies

The panel reviewed the status of technologies in the non-lethal effects area with varying impressions of the maturity for application to OOTCW. Some technologies are ready for packaging for Air Force applications, and this packaging will introduce some challenges. For other technologies, there are clearly some frailties that must be addressed in development. Nevertheless, it seemed evident that non-lethal weapons should take their place in the arsenal and that the needed attendant planning and effectiveness tools should be provided.

In selecting technologies for Air Force applications, the panel leaned toward antimateriel effects as more desirable than antipersonnel effects. This was to take advantage of the greater political acceptability of antimateriel weaponry.

Technology Summary

The technologies to be considered were many, and this study could address but a few. In the view of the panel, the primary emphasis should be on those non-lethal effects that can be delivered by airpower, recognizing that Air Force security forces, for example, might include non-lethal weapons in the performance of their functions. Ground application of non-lethal means were considered to be of short range and hence fell into the category of "police" activity, an area being addressed extensively by JNLWD as well as by the civil and military police agencies.

The primary candidates for delivery by airpower were determined to be:

- HPM
- high-energy lasers
- EMP
- information warfare
- communications jamming
- psychological warfare
- calmatives
- obscurants
- flash-bang
- super lubricants
- irritants
- barriers
- nets
- sticky foams
- optical coatings
- POL contaminants
- embrittlement agents
- conductive particles
- depolymerizing agents
- supercaustics

There are also a number of non-lethal technologies that are not necessarily compatible with aerial delivery but have potential Air Force application for ground combat, peacekeeping, and humanitarian operations:

- acoustic wave
- stun devices
- blunt impact projectiles

Of the technologies reviewed, the directed-energy technologies appear to have the highest payoff. Within the directed-energy category, the HPM appeared to have the most potential for near-term Air Force use. HPM energy appears suitable for the disruption, disabling, or damaging of electronics equipment in which semiconductor materials and devices are extensively used. This could include laptop computers, weapons, and vehicles with electronic computer-based ignition systems. An HPM "gun" that could be mounted in an aircraft is conceivable.

The use of lasers to damage equipment has been the preferred option for boost phase intercept of ballistic missiles from airborne and space platforms. Beyond that application, however, there are opportunities for the use of high-energy lasers of a more modest size (and, hence, range) from platforms such as the AC-130U gunship or the CV-22 special operations aircraft. The panel believes that this implementation could be suitable for a 20,000-foot range of application against soft targets such as fuel tanks, light vehicles, and aircraft on the ground.

Lower-power continuous-wave laser weapons would be practical for disabling EO sensors on air defense systems, night-vision devices, weapons, and surveillance systems. These low-power laser weapons could be conveniently placed aboard aircraft for both offensive and defensive applications. AFRL believes such systems could be ready for EMD in the 2005 to 2015 timeframe.

The low-power lasers are focused-energy lasers and thus, in general, are one-on-one or one-on-few weapons techniques. The related area of isotropic optical radiators would provide a short-duration, high-optical energy that could disorient but not permanently blind both electro-optic sensors and personnel. A variation is to include a loud, but nondamaging explosion such as the "flash-bang." Either of these devices might be effective, for example, to cover insertions/infiltration and to disorient or discourage personnel from approaching an aircraft involved in noncombat evacuation operations, infiltration operations, rescue, or even food delivery, particularly during dusk, night, or dawn.

HPM weapons have been described above as directed-energy devices or guns. A related technology deals with the explosive, or explosively aided generation of an EMP, also suitable for the disruption, disabling, or damaging of laptop computers, command and control (C^2) systems, weapons systems, and vehicles. Such devices have been demonstrated[36] to be effective against vehicles. While these EMP devices have a short range of effectiveness, they probably could be packaged in air-deliverable mines and gunship-caliber projectiles for Air Force precision delivery.

The advent of both defensive and offensive information operations has been a great advancement in warfare in the last decade. IO are very broad in spectrum, very deep in levels of employment, and very diverse in technology needs. The techniques, systems, and concepts for the attack of information systems depend on surprise, and hence the closest possible security measures must be followed during development and employment of IO. This study did not penetrate the attendant security restrictions and therefore this report will not comment on technologies that may or may not be in development. The panel did, however, consider the electronic warfare and PSYOP areas within IO.

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[36] Discovery Channel Documentary, "Shoot Not to Kill."

A completely different non-lethal means (as defined for study purposes only) is communications jamming. The Air Force capability for communications jamming is currently the EC-130 Compass Call jamming aircraft.

AFSOC equips and maintains 5 EC-130E Commando Solo psychological warfare aircraft with high-power radio and television transmitter systems for the transmission of PSYOP broadcast material. PSYOP are basically the same as they have been for decades. Operational concepts could well be expanded to include applications for disaster relief, tactical deception, and humanitarian assistance. The technical concepts have not been modernized to take into consideration the introduction of multimedia information techniques, computers, compact transmitters, low-cost expendable air-droppable radio and TV receivers, the Internet, and small video cameras. UAVs would appear to provide an excellent platform for long-endurance PSYOP transmitter systems.

The use of acoustic weapons has drawn speculation[37, 38] that it might be very effective against crowds, however, the test results left doubt that the fundamental mechanisms were established and the application approaches determined. While the panel was not against the use of pulsed, interrupted continuous-wave, or continuous-wave acoustic approaches, the panel feels that further research, development, and testing are needed.

Optical disorientation devices use lights, strobe effects, and other techniques to confuse and disorient personnel. The techniques are known to be effective in low-light conditions, but effectiveness in daylight is a problem. The panel recommends continued monitoring of technology developments in this area to assess applicability and effectiveness to Air Force mission areas.

Stun devices such as the COTS Taser are in use by law enforcement and force protection personnel worldwide. These devices are for use from very close (inches) to close (feet) ranges. Effectiveness of the devices varies. Some highly aggressive individuals have continued to attack even after repeated use of the stun device.

A more contentious antipersonnel non-lethal means is the use of toxic or nontoxic incapacitating agents. Toxic agents are those that cause an internal effect such as sedation, while nontoxic agents include those that create noxious odors. The Air Force could deliver such agents from bomb-like canisters, from small canisters launched from cluster bomb units (CBUs) or flare dispensers, fired as gun projectiles, or applied as an aerial spray. The big question, however, is the acceptability of the measure in the eyes of the American public, regardless of the international and national law and policy. It is a matter of whether the agent could directly or indirectly cause “unnecessary suffering” in individuals. There is a similar moral issue with the use of chemical agents against crops. Producing hunger is considered as causing unnecessary suffering. On the other hand, regarding illegal drug crops, U.S. Southern Command has supported research on chemicals that are inactive until activated by the sugars from certain drug-producing plants. Upon activation, they destroy the illegal crops but have no effect on food crops.

Obscurants have been used on the battlefield since ancient times. Aerial delivery of smoke munitions is a well-established non-lethal application.

Flash-bang devices are also in worldwide use to distract, confuse, and demoralize personnel. Usual applications are for use indoors, but outdoor use and aerial delivery are viable options. These devices can range in size from small grenades to the 15,000-lb. GBU-82 weapons used during Desert Storm.

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[37] Col Joseph Siniscalchi, “Non-Lethal Technologies: Implications for Military Strategy,” Air University, March 1998.

[38] Col John L. Barry, et al., “Non-Lethal Military Means: New Leverage for a New Era,” Harvard University National Security Program Policy Analysis Paper 94-01, 1994.

Super-lubricants, applied to runways and taxiways, roads and highways, pedestrian paths, and stairways are useful for slowing the movement but only as a delaying tactic and only for a relatively short period. Longer-term persistence would be useful for the denial of non-lethal airfield and transportation system operations. The Air Force should encourage JNLWD to undertake development of agents and application techniques suitable for aerial and airfield applications.

Irritants such as pepper spray and CS gas have a place in the Air Force non-lethal inventory. The most obvious application is for personnel protection, although aerial delivery is feasible.

Barriers are in worldwide use for crowd and traffic control. Ground delivery and emplacement is the norm. There is some potential for aerial delivery.

Projectile- and munition-delivered nets also have been developed for crowd and vehicular traffic control. Delivery accuracy and geometry are challenges, but commercial suppliers claim development of feasible solutions. There is potential for aerial delivery using highly precise munitions.

The use of sticky foam has been demonstrated to the public [39] and by Sandia Corporation personnel to the study team. This technology has been used by police agencies and was used in Somalia by the Marine Corps. In the panel's review of the sticky foam work, it appeared that weapons to date are capable of disabling only a few persons at short range. Air-deliverable munitions apparently are under development for antimateriel applications but the panel remains skeptical about the utility of airborne delivery of sticky foam against personnel. Sticky foams are also under development as containment devices for anti-WMD destruction systems. The panel speculates that similar foams could also function as environmental containment barriers while aggressive supercaustic or depolymerizing agents attack underlying material targets (see below).

Optical coatings have been developed for use against transparencies by law enforcement and military agencies. Conceivably, the coatings could be adapted for non-lethal attack against aircraft transparencies and weapon and aircraft electro-optical apertures.

Petroleum, Oils, and Lubricants (POL) contaminants appear to have potential for rendering adversary POL supplies unusable. If environmentally acceptable materials and effective aerial delivery techniques can be developed, this non-lethal attack technique will find wide-scale application in anti-airfield and antitransportation system operations.

Air-deliverable conductive particles and fibers apparently are quite effective against electrical power grids and high-voltage equipment [40, 41, 42, 43, 44]. The panel speculates that conductive foams might be even more effective since they could persist on their intended targets for substantially longer periods than airborne particles and fibers.

There appear to be a range of air-deliverable, chemically aggressive (caustic, clogging, and embrittlement and depolymerizing) antimateriel agents capable of non-explosively disabling vulnerable elements of selected target classes, including mechanized equipment, artillery, and electrical and electronic

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39 Discovery Channel Documentary, "Shoot Not to Kill."

40 Col Joseph Siniscalchi, "Non-Lethal Technologies: Implications for Military Strategy," Air University, March 1998.

41 Col John L. Barry, et al., "Non-Lethal Military Means: New Leverage for a New Era," Harvard University National Security Program Policy Analysis Paper 94-01, 1994.

42 David Fulghum, "Navy Claims New Tricks Await Foes," Aviation Week and Space Technology, 15 March 1999.

43 David Fulghum, "Electronic Bombs Darken Belgrade," Aviation Week and Space Technology, 10 May 1999.

44 Jim Drinkard, "Airstrikes Short-Circuit Yugoslavia," USA Today, 4 May 1999.

equipment. Techniques for aerial application including dispensers, PGM, mines, bombs, and projectiles should be investigated for Air Force application.

Application Assessment

The analysis of the technology solution concepts formulated by the panel continued with a look at what the application might be. In this analysis, the panel made some projections for applications, accompanied by an assessment of the utility of the technologies to Air Force missions, with due consideration to compatibility with airborne delivery platforms.

Table 6-7 provides the result of assessing the application of the technologies.

Table 6-7. *Technology Applications*

Non-Lethal Category	***Technology***	***Antimaterial***	***Antipersonnel***	***Utility***
High-Powered Microwave (HPM)	HPM (Continuous Wave)	X		M
	HPM (Pulse)	X		H
Laser	Laser (High Power); (Pulse)	X		H
	Laser (Low Power)	X		M
Information Warfare	Communications Jamming (Electronic)	X		H
	Directed Energy	X		M
	Info Attack (Computer Viruses, etc.)	X		H
PSYOP	TV/Radio/Acoustics		X	M
	Directed Energy	X		H
	PSYOP (Things)		X	M
Other	Acoustic Wave		X	L
	Optical Disorientation		X	M
	Stun Devices		X	M
	Blunt Impact Projectiles		X	M
	Calmatives		X	M
	Obscurants	X	X	M
	Flash-Bang		X	M
	Super Lubricants	X	X	M
	Irritants		X	M
	Barriers	X		M
	Nets	X	X	L
	Sticky Foams	X	X	M
	Optical Coatings	X		M
	POL Contaminants	X		H
	Embrittlement Agents	X		M
	Conductive Particles	X		H
	Depolymerizing Agents	X		H
	Supercaustics	X		H

Maturity Assessment

The panel’s next step was to assess the maturity of the technologies, that is, to project when the technology, in a packaging appropriate to airborne delivery, could be demonstrated and become available for EMD. Table 6-8 provides the results of the assessment. In Table 6-8, the symbols represent time scales: N—EMD within 5 years, M—EMD between 5 and 10 years, and F—EMD beyond 10 years.

Table 6-8. *Technology Maturity and Packaging*

Non-Lethal Technology	20-, 25-, 30-, 40-, and 105-mm bullets for fighter and gunship aircraft	ALE-40, 47 dispenser	New gun for gunship	New gun for roll-on for other aircraft	CBU dispenser	Pods	Air-delivered mines	Bombs	Other aircraft (transmitter)	UAV
HPM (CW)			M	M-F		N			M-F	M-F
HPM (Pulse)	M-F	F		M-F		N-M	F		M	M
Laser (High Power)			M	M		M-F			M	M
Laser (Low Power)			M	M		M			M	M
Communications Jamming		N-M			N-M	N-M	N-M		N	M
Directed Energy (electronic warfare)	F		F	F			F		F	F
Info Attack			M-F	M-F		M-F	M-F	M-F	M-F	M-F
PSYOP (TV and Radio)									M-F	M
PSYOP (Directed Energy)			M-F	M-F		M-F			M-F	M-F
PSYOP (Things)		N			N			N	N	N
Acoustic Wave			F	F		F			F	
Optical Disorientation	N-M	N-M			N-M		N-M	N-M		N-M
Stun Devices	N-M	N-M			M		N-M	N-M		N-M
Blunt Impact Projectiles	N				N-M		N-M	N-M		N-M
Calmatives	M	M			M	M	M	M		M
Obscurants	N	N			N		N	N		N-M
Flash-Bang	N				N-M		N-M	N-M		N-M
Super Lubricants		N			N		M	MN		N-M
Irritants	N-M	N-M			M		N-M	N-M		N-M
Barriers			M				M	M		
Nets			M				M	M		
Sticky Foams	N-M	N			N		N	N-M		
Optical Coatings	N-M	N			N		N	N-M		
POL Contaminants	M	M			M					M
Embrittlement Agents	M	M			M					M
Conductive Particles	N-M	N-M			N-M			N-M		N-M
Depolymerizing Agents	M	M			M					M
Supercaustics	M-F	M-F			M-F					M-F

Utility Assessment

A utility assessment of the various non-lethal technologies is more complex than for lethal weaponry because of the concern that the risk to noncombatants is of great consequence, whether it be actual injury or death. The pervasiveness of the news media in crisis zones adds urgency to the consideration. So beyond the basic needs to evaluate effectiveness and affordability, other considerations and ranges are important.

Table 6-9 provides the results of the assessment. In order to provide and compare relative scores for the considered technologies so as to prioritize the recommendations, the panel developed a scoring method as shown in Table 6-10.

Table 6-9. *Assessment of Utility*

Non-Lethal Technology	Effectiveness	Affordability	Accessibility	Development Time	Delivery Range	Discrimination	Delivery Precision	Launch Precision	Coverage	Time to Effect Result	Length of Effectiveness	Collateral Damage	Reversibility	Vulnerability to Countermeasures	Vulnerability to Antidotes
HPM (CW)	H	M	M	L	H	H	H	H	M	H	M	H	H	M	na
HPM (Pulse)	H	M	M	L	L	H	H	H	M	H	M	H	H	M	na
Lasers (High Power; Pulse)	H	M	H	M	H	H	H	L	M	H	M	H	L	M	na
Lasers (Low Power)	H	H	M	H	H	H	H	M	M	M	M	H	H	M	L
Communications Jamming (Electronic)	H	M	L	M	H	H	H	H	H	H	M	H	H	H	na
Directed Energy (IW except PSYOP)	H	M	L	M	M	H	H	H	M	H	M	H	M	M	H
Information Attack (Comp Viruses)	H	M	L	M	H	H	H	H	H	H	H	H	H	L	M
PSYOP (TV/Radio/Acoustics)	M	M	L	H	H	M	H	H	H	H	H	H	H	L	L
PSYOP (Directed Energy)	H	M	L	M	M	H	H	H	H	H	H	H	H	M	M
PSYOP (Things)	M	H	L	H	H	M	L	H	M	L	M	H	L	L	na
Acoustic Wave	L	M	L	L	L	L	L	M	M	H	L	M	L	L	na
Optical Disorientation	H	H	M	H	M	M	L	M	H	H	M	H	H	M	na
Stun Devices	M	H	M	H	L	M	M	H	M	H	L	H	H	L	na
Blunt Impact Projectiles	M	H	M	H	L	M	M	H	M	H	L	H	H	L	na
Calmatives	H	H	M	M	M	L	L	L	H	M	M	H	H	M	L
Obscurants	H	H	M	H	M	L	M	M	H	H	M	H	H	H	na
Flash-Bang	H	H	M	H	M	L	L	M	H	H	M	H	H	M	na
Super Lubricants	M	H	M	H	M	L	L	H	H	H	M	M	M	M	na
Irritants	H	H	M	M	M	L	L	L	H	M	M	H	H	M	L
Barriers	M	H	M	H	L	L	M	H	L	H	L	H	H	L	L
Nets	M	H	M	H	L	L	M	H	L	H	L	H	H	L	L
Sticky Foams	M	H	M	H	L	L	L	H	M	H	H	L	H	L	na
Optical Coatings	H	M	M	M	M	L	M	H	M	M	M	M	M	M	na
POL Contaminants	H	L	H	L	M	H	L	L	H	H	H	H	L	H	na
Embrittlement Agents	M	M	H	M	L	H	M	H	M	M	H	M	L	L	na
Conductive Particles	M	H	H	H	M	H	M	H	H	H	M	H	H	H	na
Depolymerizing Agents	M	M	H	M	L	H	M	H	M	M	H	M	L	L	na
Supercaustics	M	H	H	M	L	H	M	H	M	M	H	L	L	M	na

Table 6-10. *Scoring of Utility—A Guide*

Utility Category	Low	High
Effective	Not likely to create desired effect	Very high likelihood of creating the desired effect
Affordable	Very expensive to develop or produce	Very reasonable cost of development production and use
Assessable	Very difficult to measure effectiveness	Effectiveness can be quantified
Development Time	Long: Technology immature	Mature technology: Ready for implementation
Delivery Range	Short	Long or variable
Discrimination	Low	High
Launch Precision Required	Beyond state of the art	Achievable now
Delivery Precision Required	Beyond state of the art	Achievable now
Coverage	Fixed area	Tunable coverage
Length of Effectiveness	Fixed period	Variable
Time to Effect Result	Long	Short
Collateral Damage	Likely	Not likely
Reversibility	Effect is not reversible	Simple method of reversing effect by United States
Countermeasure Vulnerability	Susceptible to simple countermeasures	No known countermeasure
Antidote	Enemy can possess simple antidote	No known antidote

6.4 Findings and General Recommendations

6.4.1 Findings

- Non-lethal weapons can meaningfully and significantly expand the options available to a commander in times of increasing tension, as well as during armed conflict
- The Air Force lacks a comprehensive strategic vision or plan for the inclusion of non-lethal weapons in OOTCW
- Non-lethal options available to the Air Force are limited, and none are long range or packaged for airborne delivery
- Electronic warfare, IW, and PSYOP are force enablers that support the Air Force core competency of information superiority, yet no coordinated program exists for their synergistic integration into Air Force operations
- Many non-lethal (and lethal) weapons can benefit from delivery by platforms that provide persistence through long-endurance flight over a potential target
- It is desirable to possess a range of lethality options commensurate with a given scenario; currently, non-lethal antimateriel capabilities do not exist in the Air Force for use against electronic and non-electrical equipment

6.4.2 General Recommendations

1. Develop a comprehensive strategy that takes into full account all potential roles and uses of non-lethal weapons, including delivery of non-lethal effects from air or space for strategic or tactical purposes. The Air Force can and will be a major component in the nation's capability to prosecute OOTCW. Its strategy, vision, and plans must reflect how aerospace power can contribute using non-lethal weapons and means to ensure increased relevance in the 21st century. Toward that end, its leaders must be educated in non-lethal warfare, and the development of Air Force capability must focus on weapons that can be delivered from space.

2. Integrate the use of non-lethal resources into the campaign and mission planning processes so that their employment is as natural an option, when appropriate, as lethal resources. Non-lethal means should augment and be integrated with (1) conventional weapons for air combat, strategic strike, special operations, and other combat operations, and (2) noncombat command units such as intelligence, surveillance, and reconnaissance (ISR), airlift, and security police. In order to support this integration, the effects of non-lethal resources must be understood and quantified in meaningful measures of effectiveness, planning tools must be developed to facilitate their integration into an overall campaign plan, and means of estimating BDA must be established. The JMEM series must be expanded to include non-lethal effects and weapons. The non-lethal means should be an equal consideration in the Joint Force Air Component Commander's planning process.

3. Define a vision that realizes the "variable lethality" concept. This vision would have the practical equivalent of ammunition with lethality that can be adjusted just before delivery. To the extent possible, concepts should be compatible with current weapons packaging (for example, cartridges, bomb casings, and directed-energy systems) and weapons platforms (for example, fighters, bombers, gunships, and unmanned combat air vehicles). However, nontraditional concepts may emerge, such as C-17s used to deliver swarms of lethal and non-lethal PGMs with target designation from, perhaps, ISR platforms and off-board human controllers.

4. The Air Force must "catch up" and cooperate with the other Services in the ability to effectively employ non-lethal capabilities. The Air Force should officially endorse the application of non-lethal means, by endorsing the *Multi-Service Procedures for the Tactical Employment of Non-Lethal Weapons* (FM 90-40) in use by other Services. Furthermore, the multi-Service tactics, techniques, and procedures (MTTP) contained in the document should be immediately expanded for strategic and tactical aerospace application. As it is now, all other Services have endorsed and used the current MTTP; knowledgeable Air Force personnel helped write it, but there is no official acceptance of an Air Force role in delivering non-lethal weapons.

5. Develop a comprehensive acquisition strategy to develop, test, and procure, non-lethal weapons for air operations. A comprehensive, balanced acquisition research, development, test, and evaluation (RDT&E) plan should be developed to field non-lethal weapons and platforms, or weapons and platform modifications, and to fund the technology base programs needed for evolving non-lethal effects requirements. The Air Force must not neglect the equally important technology programs needed for evolving the knowledge base of non-lethal effects, as well as those for countermeasures to the effects, should the adversaries acquire the same capabilities. Of particular importance are:

- Human effects research
- Psychological effects research
- Measures of effectiveness development
- Public affairs release plan development

6. Implement effects-based methods to drive all weapons requirements, development, and use. Requirements for lethal and non-lethal weapons must be driven by the effects that are needed. There is recognition of the need to implement effects-based methods for operational planning and to extend these methods to other areas, such as requirements definition and test and evaluation for new (and non-lethal) weapons. However, there are missing tools, methods, and procedures available to commanders, planners, and RDT&E personnel that can guide them in determining the effects necessary to fulfill a mission, and the effects that the weapons (including non-lethal weapons) can produce. The Air Force should learn and use knowledge that is available from other Services (for example, knowledge about suppression algorithms) to plan for the operational effects of non-lethal weapons and to assess their effectiveness.

7. Develop capabilities to assess, in real time, the effects of applied non-lethal means on adversaries (BDA) for planning and operations. Systems and technologies are needed to conduct BDA that quantifies non-lethal effects. The missing link in the chain from shooter-to-effect is the BDA link that provides timely and accurate feedback on the effects that are achieved. This is especially critical for non-lethal effects that may be difficult to assess (for example, incapacitate) and temporary (for example, for "x" minutes, starting at "y" o'clock).

8. Expand the use of non-lethal resources in the full spectrum of conflict during participation in Air Force–specific and joint warfighting experiments and exercises. The Air Force should take a more aggressive approach to deriving "system requirements" and operational concepts for non-lethal weapons through experimentation in joint-Service and traditional training (for example, Red Flag) exercises. This includes much more collaboration with the other Services to derive *common systems and tactics*.

6.4.3 Recommended Initiatives

On the basis of this study, the panel recommends the following development initiatives, in order of priority:

1. HPM (Continuous Wave) — **Demonstrate an HPM/continuous wave "gun" suitable for integration into an aircraft.**

The demonstration of HPM in an airborne application should be possible. The panel believes that the development of a non-lethal airborne option would be valuable to the Air Force. The integration of an HPM capability into an aircraft is not a trivial problem. Power, weight, antenna location, and drag issues must be addressed. These problems have an operationally useful solution, and the panel encourages the Air Force to demonstrate the HPM aircraft application in the near future.

2. HPM (Pulse) — **Demonstrate air-implantable HPM/Pulse (EMP) "mines" that could be used to halt or delay movement along lines of communication.**

Interdiction is an important Air Force mission. A primary part of interdiction is stopping vehicles to prevent supplies from reaching enemy units. The panel does not have a non-lethal option for vehicle stopping, but pulsed HPM may offer a possibility, at least for those vehicles with electronic ignition systems. A non-lethal, air-deliverable HPM antivehicle mine is a possibility. Such a device could stop vehicles with electronic ignition systems—a large fraction of passing vehicles. It could also disable electronic instruments passing within its field of regard on their way to the front. There are significant questions of alignment, power, and tamper resistance to be solved, but sensor-triggered, explosively driven power supplies should be developed. It may be that the issues cannot be resolved, but the possible payoff will justify some work and thought on the possibilities.

3. HPM (Continuous Wave or Pulse) **Develop HPM as a self-protection system for aircraft.**

A high priority for application of HPM is for aircraft self-protection. Both pulsed and continuous wave systems may be useful for this application. At present there is no capability, other than electronic warfare, for defeating radar-guided missiles, and only flares are available for defeating IR missiles. And with IR seekers becoming more effective, flares will be nearly useless. HPM offer the possibility of upsetting missile electronics to defeat both radar and IR seekers.

4. Laser (High Power) **Accelerate development of all-solid state laser device technology for compact, antimateriel gunship, and fotofighter applications.**

Solid-state laser technology can become the preferred laser device technology, especially for airborne applications, because of its dependence on electrical power rather than consumable chemical laser sources. The enabling technologies show the potential for high-power applications and for array concepts to eliminate the need for steerable optics; however, continued development should be accelerated to demonstrate technical maturity and operational effectiveness with airborne compatible packaging.

5. Laser (High Power) **Demonstrate the utility of ABL or ATL for non-lethal antimateriel applications against low-altitude and ground-based targets, and experiment with operational concepts in joint exercises.**

Laser development has proceeded to the point that laser power needed to damage aircraft and ground targets will soon be available in packages small enough to carry aboard an aircraft. For large aircraft, such as a Boeing 747, the acceptable gross weight can be 170,000 pounds, but for smaller aircraft, the maximum weight may be as low as 20,000 pounds. Demonstrations of the ABL's ability to achieve non-lethal effects on *airborne and ground-based* targets should be planned. Furthermore, operational concepts to employ ABL should be developed during joint exercises. ATL system and operational concepts should be pursued as well.

6. Laser (Low Power) **Evaluate the spectrum of uses that may be appropriate for low-power laser for air employment.**

Low-power lasers have been used as target designators for PGM and as crowd-confusing devices during the extraction of Marines from Somalia. The PGM application has been instituted within the entire U.S. military, but other uses are not yet widely accepted. Laboratory work continues on lasers having power levels below the eye damage limit but above the levels required for disorientation. Optimum designs have not yet been determined, but the technology has evolved to the point where devices can be demonstrated. The panel recommends that such demonstrations use airborne platforms and that device designs be optimized.

7. Compact Electric Generator **Accelerate compact, lightweight, high-efficiency aircraft electric prime-power-generation components to enable directed-energy applications.**

HPM and laser weapons require significant amounts of power. Power levels in the megawatt range are required. Analyses of generators using high-temperature superconductors have shown that significant power can be extracted from a turbine engine using superconducting wires in a magnetic field. Development of conductors and new fabrication techniques are necessary to make the superconducting generator a reality. These appear to be within current capabilities of materials development and fabrication. The panel recommends that the Air Force fund technology and demonstration programs to

show that megawatts can be generated from a turbine engine using high-temperature superconductor technology.

8. Communication Denial **Develop small (baseball-size or flashlight-size) expendable jammers with a moderate-duration life (72 hours), suitable for manipulating cellular telephone systems, handheld radios, and GPS receivers.**

The technologies for extremely small jammers exist today. Air Force aircraft with CBU dispensers or flare and chaff dispensers could seed areas in which cellular telephones, handheld radios, or even GPS receivers are being used to military or terrorist advantage to disrupt the control communications essential to their success. The jammers could be deployed to strike and cling to the tops of the antenna towers of cellular systems to provide continued disruption of the system and difficulty in locating the source of disruption.

The technical concept would be to develop small (baseball- or flashlight-size) expendable jammers with moderate-duration life (72 hours) that could jam for a few minutes each time a transmission is detected on a frequency. These could be programmed and loaded into the chaff or flare dispenser such that the aircrew could select the set for the specific operation to be disrupted.

The same technologies would offer the opportunities for short-duration continuous jamming of the GPS receivers associated with weapon delivery. These jammers could even be activated remotely with a short coded sequence sent with the GPS signal that would include the duration of the jamming signal, thus providing a longer total useful lifetime.

9. Electronic Warfare **Demonstrate the utility of a UAV in an electronic warfare role to augment or extend the range of existing capabilities.**

The UAV (particularly Global Hawk) offers an ideal platform for jamming radar and communications nodes. With high-altitude and long-endurance capabilities, coupled with the advantage of self-deployment from the continental United States (CONUS) locations, the system could be quickly launched and selectively employed for specific critical missions from CONUS ground-based control stations. Thus the commander could identify situations in which jamming of a wide range of signals would be beneficial and could task or control the jammers to precisely interfere with the conduct of the adversary's activities.

The technical capability to accomplish the task is based on existing jamming technology. The high-altitude, long-endurance UAV offers the opportunity to operate closer to the battle area providing two advantages: (1) greater visibility to target receivers and (2) reduced jammer RF power requirements (which translates to a reduced system weight). Communications nodes can be selectively disrupted, allowing for an organized effort to confuse the adversary.

10. Electronic Warfare **Develop a capability of locating communications and radar jammers with sufficient accuracy and identification so that they may be attacked with existing weapons.**

Just as jamming is effective in disrupting an enemy's capability to manage the battle, the enemy's jamming adversely affects U.S. operations. Thus, it is essential that the United States be able to quickly and accurately locate such jammers for targeting and destruction. The coherent time-difference-of-arrival emitter-location technology developed originally by the Air Force and actually fielded by the Army allows for long-distance precision geolocation of jamming signals of any type of waveform from airborne platforms. Though a dedicated system (the Precision Location Strike System) was originally envisioned

for the task, modern technology provides for the use of small receiver-processor packages, along with datalinks and multiband antenna systems, as parasitic of roll-on and roll-off packages (100 lb) for any manned or unmanned aircraft.

11. Information Attack **Explore a range of field-usable (line-of-sight) information-attack weapons for disruption of local control authority.**

Directed energy, such as high-power microwave signals, can be employed to disrupt communications nodes and switching centers highly dependent on computer-based processing and switching. The technology and the specific delivery approaches were discussed in an earlier section.

12. Directed Energy (IW) **Continue to develop and demonstrate directed-energy applications for various anti-electronics IO, including PSYOP.**

The Air Force should continue to develop and demonstrate directed-energy applications for various anti-electronics forms of IO, including PSYOP. The dependence of military systems on computers for early detection makes them particularly vulnerable to these types of offensive IW attacks. Infrastructure systems, such as power generation and distribution, water supply, logistical tracking and supply, and financial management are also increasingly dependent on computers and are vulnerable to attack. Disabling these systems temporarily or without heavy physical destruction could significantly benefit operations in urban warfare or situations where the United States may want to use captured facilities and infrastructure. Using directed energy to disrupt or spoof electronics to divert the enemy's attention to a false area or away from the primary area of action could substantially augment the conduct of military operations, particularly clandestine operations and SEAD.

In addition, the ability to use radio-frequency radiation applications from airborne platforms (for example, manned or unmanned) to emulate or insert computer viruses could also provide a great military capability and skirt policy issues regarding the use of computer virus attacks via the Internet. Using directed energy to disrupt or spoof cellular telephones could boost capabilities for counterdrug operations and operations in Third World countries, where cellular telephones may serve as the primary C^2 infrastructure. The possibility of using lasers or RF radiation to insert voice transmissions over open or encrypted telephones, cellular telephones, or computer communications could revolutionize PSYOP and IW. The ability to insert altered or mimicked voice transmissions could transform deceptive operations. Finally, the possibility of using multispectral directed energy to broadcast PSYOP messages at long-range or over very wide or focused target areas in a generic fashion to all possible target sets would greatly enhance the Air Force's current PSYOP distribution capabilities.

Several possible IO applications are documented in the classified version of the Directed Energy Applications for Tactical Airborne Combat (DE ATAC) Study's Phase I report (March 1999). Two particularly interesting concepts from the DE ATAC Study are "Buzz" and "Hello." These two concepts have applicability to both PSYOP and IW.

13. Psychological Operations **Request the U.S. Army provide a cultural modeling, prediction, and assessment capability for Air Force PSYOP mission planning.**

Successful conduct of PSYOP or IO campaigns is highly contingent on being able to provide the right types of information to the targeted population that will motivate them to maintain or change their behavior to conform with U.S. objectives. The PSYOP material must be culturally tailored for it to provide the biggest impact for the lowest cost. The United States is lacking in its ability to model and predict the impact of cultural factors, such as religious ferver and superstitions, societal norms and taboos,

or political dogma, on its application of force, including IW and PSYOP. Although the panel has been informed that NIJ has some cultural assessment capability, it is unknown how thorough and appropriate the capability is for military PSYOP planning and execution.

The Army is the lead Service for PSYOP materials development. The Air Force is responsible for airborne PSYOP distribution and Air Force planning of PSYOP campaigns. Successful accomplishment of the Air Force PSYOP mission will depend on its ability to understand the cultural factors relating to its PSYOP campaign and assess the impact of the delivery of the PSYOP products developed by the Army. Therefore, the Air Force should require the U.S. Army to provide a cultural modeling, prediction, and assessment capability for Air Force PSYOP mission planning. As the lead Service for PSYOP materials development, the Army should be responsible for funding the development of this predictive tool and integrating it into the planning cells within the other Services and USSOCOM.

14. Psychological Operations **Develop a UAV or small, inexpensive manned aircraft capability to deliver PSYOP and IW.**

The Air Force should develop a UAV or small, inexpensive manned aircraft capability of delivering PSYOP and IW. The North Atlantic Treaty Organization commanders were not able to optimally use the Air Force EC-130E Commando Solo aircraft during the Kosovo conflict because of standoff range and survivability issues. These issues drove a classified Combat Mission Needs Statement that will better enable use of Commando Solo assets in similar operations. One promising way to augment Commando Solo is to use UAVs. PSYOP UAVs would be particularly advantageous for broadcasts in high-threat environments. These UAVs could be launched separately or in concert with EC-130Es. If AFSOC's long-range vision for an EC-X replacement for Commando Solo is realized, UAVs could be launched from and recovered by the aircraft, and could serve as relays or independent broadcast mechanisms.

Small, inexpensive manned aircraft could also be used to deliver PSYOP and IW to augment Air Force capabilities. These manned aircraft are likely to have a small signature that would enable high-risk operations. They could provide a cost-effective method for enabling short-range, focused PSYOP delivery to augment larger EC-130 assets. They could provide an interim capability until PSYOP UAV platforms are developed and employed.

15. Materiel Denial Agents **Develop air-deliverable antimateriel weapons for use against electronic and non-electronic materiel targets.**

The Air Force has no options to deny adversary non-electric and non-electronic equipment and artillery except lethal force. The panel recommends consideration of combinations of non-lethal techniques such as aggressive agents plus sticky foams and perhaps even encapsulating nets. In combination, a precisely delivered non-lethal weapons could environmentally cocoon a target while aggressive chemical and polymer reactions render it functionally useless. Such combinations could also be adapted for electronic and electrical targets (for example, electrically conducting foams that not only short out electrical circuits but also do so for long periods).

The technologies and capabilities developed could have broad application to other Air Force mission areas (for example, anti-nuclear, biological, chemical attack). Non-lethal materiel denial agent development should focus on system concepts that will be environmentally acceptable with minimum personnel toxicity; otherwise, employment of the systems will be so constrained that they may not be truly viable options to lethal attack. The antimateriel agents, therefore, will probably be tailored against specific materiel systems only. The Air Force should be the lead Service for development of air-deliverable materiel denial agents and munitions.

16. Airfield Operation Denial Agents **Develop air-deliverable non-lethal weapons to deny or impede adversary airbase operations.**

The Air Force currently has no alternative to deny adversary airfield operation except to use lethal force. Aerial delivery of antivehicular "slicks," POL contaminants, and other non-lethal weapon systems could expand the range of options available to the Air Force before it has to resort to lethal force. Other Services and agencies are developing some of these technologies, and the Air Force needs to assess their effectiveness on airfield operations. Non-lethal technology development uniquely associated with anti-airfield operations should be an Air Force responsibility.

17. Vehicle Impeding Agents **Develop air-deliverable non-lethal weapons for use against armor and other heavy mechanized equipment.**

The Air Force has no option for disabling or impeding vehicular traffic (including armor and mechanized equipment) except to use lethal force. Other Services and agencies are developing non-lethal capabilities for use against vehicular traffic, but none appear to be targeted against moving armor and mechanized military equipment. The Air Force leads development of lethal weapons for this target class, and it should expand its options by the development of non-lethal weapons warhead technology and delivery systems as well.

18. Personnel Dispersing Agents **Provide Air Force ground combat personnel and aircrews operating in potentially hostile environments with non-lethal antipersonnel weapons.**

The Air Force air and ground crews need access to highly effective other non-lethal force protection equipment. Such systems are under development by other Services, agencies, and JNLWD. No Air Force–unique development should be required for individually issued non-lethal weapons. Integration into air vehicle offensive or defensive suites, however, will require installations unique to non-lethal weapons and need to be assessed for cost effectiveness. The Air Force currently relies exclusively on high-muzzle velocity guns for air vehicle installation and no antipersonnel non-lethal weapons projectiles exist for current guns.

19. Gunship **Develop non-lethal delivery capability for gunships.**

Air Force gunships operate on the principle that an aircraft orbits around a target delivering munitions fired from the left side of the aircraft, perpendicular to the axis of the aircraft fuselage. Although existing Air Force gunships, AC-130H/Us, fire 20-, 25-, 40-, or 105-mm rounds, a gunship based on any large aircraft could be used to deliver lethal and non-lethal effects. The Air Force should conduct an AOA on gunships to explore the utility of the present family of gunships as well as other solutions to the delivery of lethal and non-lethal effects in both major theater wars and OOTCW. The 1999 Senate Armed Services Report, DoD Authorization, contained language directing DoD to submit an analysis of requirements for gunships, including the relative costs of using C-130s or another aircraft. Although that report was due back to the Congress by 1 March 1999, no AOA has yet been started by OSD or the Air Force. It is recommended that the Air Force accomplish the congressionally mandated study and include non-lethal uses of gunship platforms in its analysis.

20. Psychological Operations **Select a next-generation PSYOP aircraft to replace the aging, out-dated capability now assigned to the EC-130E.**

An AF/CC-directed AOA has been contracted by AFSOC to determine the best approach in replacing the present EC-130E Commando Solo aircraft. AFSOC's MAP for IO[45] lays out its vision to enhance the

[45] See *AFSOF 2025*, Headquarters AFSOC Publication, 1995.

AFSOC role in PSYOP using a more capable, commercial-variant large-bodied aircraft, such as a 767, to replace the EC-130E aircraft. This conceptual aircraft, called the EC-X, would allow for enhanced capabilities, such as producing and disseminating PSYOP materials on board, providing a platform for high-powered, multispectral broadcasts, and possibly serving as a mother ship for launching or recovering PSYOP and IO UAV platforms. Prudence dictates that funds to cross-deck the EC-130E Commando Solo equipment to the EC-130J should not be expended until the AOA is complete.

Though C-130J aircraft is a candidate to replace the aging C-130E airframes[46], the expanded use of psychological operations requires additional airframes to augment the manned air. UAVs could be operated from safe havens, even from the U.S. with satellite datalinks for air vehicle control and transfer of mission media, capitalizing on closer ranges, reducing the required transmitter power (and hence equipment weight) significantly.

[46] This panel is concerned that the electromagnetic compatibility/electromagnetic interference (EMC/EMI) issues related to adopting a very new all-digital aircraft (C-130J) for high power RF transmission will be severe, and a cautious approach including extensive use of both computer modeling and experimentation is crucial to success.

Appendix 6A

Non-Lethal Effects Mission Statement

The tasking to the Non-Lethal Effects Panel was as follows (note that the charter is broader than non-lethal weapons themselves, addressing aspects of information warfare, including countermeasures):

- Identify concept of operations and non-lethal needs unique to OOTCW
- Consider non-lethal effects in humanitarian missions, counter-terrorism, counter-proliferation, psychological operations, electronic countermeasures, etc.
- Assess current and planned Air Force capabilities against these needs and the staff-provided OOTCW vignettes
- Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
- Postulate evolutionary and revolutionary options and technologies for meeting these shortfalls
- Consider special effects delivered from all types of platforms (manned aircraft, UAV, space, etc.), operational employment and effects
- Include area denial operations (mine replacements) using unattended ground sensors, etc.
- Identify means for selecting and ensuring precise target/effect
- Interface and coordinate closely with the Lethal Effects Panel (especially with regard to delivery and application of weapons)

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Appendix 6B
Organizations Consulted

53rd WG/EW

Air Armament Center

Air Combat Command
- Network Operations Security Center

Air Force Information Warfare Center

Air Force Research Laboratory, Directed Energy Bioeffects Division

Air Force Research Laboratory, Directed Energy Directorate

Air Force Research Laboratory, Electronic Warfare Directorate

Air Force Research Laboratory, Munitions Directorate

Air Force Special Operations Command

Air Intelligence Agency

Air, Land, Sea Application Center

Air Staff Special Operations Division

ANSER

Joint Command and Control Warfare Center

Joint Non-Lethal Weapons Directorate

Joint Warfare Analysis Center

Office of the Secretary of Defense
- Legal

Ronald W. Terry, Lt Col USAF (Ret)

Sandia National Laboratory

U.S. Atlantic Command (now called U.S. Joint Forces Command)

U.S. Central Command

U.S. Southern Command

U.S. Special Operations Command

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Chapter 7
Lethal Effects

7.0 Executive Summary

The trends in the international environment that are relevant to lethal effects in operations other than conventional war (OOTCW) aerospace operations are small-scale conflicts, which have led to many U.S. coalition peace operations, both in permissive and non-permissive environments; terrorism, which has led to counterterrorist strike operations; and concerns about the proliferation, threat, or use of weapons of mass destruction (WMD) and ballistic and cruise missiles, which have led to a need for specialized attack capabilities. Accordingly, among the most important types of operations that are included in OOTCW are the enforcement of no-fly zones, support to peace operations, counterterrorist strikes, counterproliferation strikes to destroy WMD, and theater ballistic and cruise missile defense (TBMD/TCMD).

Members of the Lethal Effects Panel concluded that there are a number of key generic characteristics of OOTCW operations that differentiate them from major theater wars (MTWs) and can result in the requirement for excessively high performance levels, or imposition of constraints on the conduct of the operation. Among these are coalitions, which can lead to least-common-denominator campaign objectives, differences in the costs members are willing to incur, and the ubiquitous presence of the media, which emphasizes both the moral and humane dimensions of conflicts and execution errors. Also, policymakers feel the need to minimize collateral damage and friendly casualties and hence to minimize domestic opposition to operations. Another constraint is the presence of nongovernmental organizations, which can greatly complicate targeting and other aspects of the conduct of military operations.

From the standpoint of lethal effects, the foregoing suggested both the need for increased precision and an environment in which survivability can outweigh effectiveness in importance. For example, the current environment increases the need for five types of precision: precise target information in three dimensions, precise timing, precise delivery, precise tailored effects, and precise, rapid effects assessment. Furthermore, recent experience also suggests that policymakers are giving higher priority to survivability (that is, minimizing casualties) than to the effectiveness or efficiency of military operations, which suggests an increasing preference for capabilities that enhance survivability.

Finally, there are a number of factors that hinder the Air Force's ability to engage in the necessary "technology push" for revolutionary OOTCW-related capabilities. These include the current defense planning focus on MTWs and its treatment of OOTCW as "lesser included cases" and the focus in the research, development, and acquisition process on users ("customers") who, unaware of the possibilities offered by enabling technologies, are quite unlikely to generate requirements for new and revolutionary capabilities ("technology pull").

7.0.1 Key Findings and Recommendations

The panel generated five key findings and recommendations. They are as follows:

1. The Air Force should develop a family of autonomous air-deliverable lethal miniature munitions to enable tailored lethal effects on fixed and mobile targets. For mobile and relocatable targets, it should complete development of the Low-Cost Autonomous Attack System (LOCAAS) and accelerate demonstration and engineering, manufacture, and development (EMD) for buried or fixed targets, and should complete development of the Small Smart Bomb (SSB) and accelerate into EMD.

2. The Air Force should develop a robust long-dwell unmanned aerial vehicle- (UAV-) based remote-sensing capability for no-fly zone surveillance to replace low-density, high-demand (LDHD) assets. In

the short term, Global Hawk should be developed with appropriate sensor and command and control (C^2) connectivity to a theater ground station; in the longer term, connectivity should be extended to any location.

3. The Air Force should develop a capability for neutralizing chemical and biological agents in bunker storage situations without causing dispersal of the target agent or causing undue collateral damage. This requires a technology initiative to provide precise intelligence regarding the storage location in three dimensions; precision delivery of the attacking capability; and research and development (R&D) of an intense heat source.

4. The Air Force should undertake a broad program of R&D to generate capabilities to positively identify noncooperative air and ground targets. Included in this program should be a broad-based research effort by the Air Force Research Laboratory (AFRL) that includes tagging systems, multispectral or hyperspectral signal processing, and forensic signal-processing algorithms. The program should also include developing a database of nonstandard target signatures to enable signature processing and evaluation of candidate solutions, and should include developing a high-fidelity recorder for radar warning receiver (RWR) signals to allow additional correlation of targets for battle management.

5. The Air Force should develop a long-dwell autonomous capability to detect, locate, target, and strike hard-to-find mobile targets such as transporter-erector-launchers (TELs) and non-emitting integrated air defense systems (IADS) (that is, a "long-dwell LOCAAS"). This should begin with a demonstration launch of LOCAAS from an unmanned combat air vehicle (UCAV).

7.1 Introduction

7.1.1 Scope and Limitations

Scope

As described in the mission statement, the panel's work focused primarily on identifying and assessing (1) key problems and tasks in lethal OOTCW, (2) needed capabilities and performance levels for successful operations, (3) current shortfalls in the Air Force's ability to provide these capabilities and performance levels, and (4) options for addressing these shortfalls.

In its work, the panel considered a wide range of options for providing lethal capabilities that are needed in OOTCW. These included options regarding both platforms (manned, unmanned, terrestrial, and space-based platforms) and types of weapons (kinetic, high-explosive, and directed-energy weapons).

The panel also sought to identify key problems and tasks, needed capabilities and performance levels, shortfalls, and available options for addressing shortfalls in detecting, locating and targeting in OOTCW and in performing battle assessment for lethal attacks.

Limitations

The following provides an overview of the opportunities for improving aerospace power's contribution to OOTCW, classification, and access to compartmentalized or Special Access Programs.

7.1.2 Approach

The panel used the following approach in fulfilling its charge. After the initial Summer Study plenary meeting in early 1999, panel members met with and were briefed by a number of organizations that have key responsibilities for performing OOTCW—providing forces or capabilities for OOTCW or developing new capabilities that can be used in these operations. These panel meetings included combatant

commands, Air Force Major Commands and other elements, DoD components, and defense contractors doing OOTCW-relevant work.[1] An initial framework for assessing what was learned in these briefings was developed during panel breakout sessions at the Air Force Scientific Advisory Board (SAB) Spring Board meeting at the Air Force Academy in Colorado Springs and refined and applied during the Summer Study.

7.1.3 Organization of the Panel's Report

The Lethal Effects Panel's report is organized as follows:

Section 7.2 describes the panel's views on the key characteristics of the environment for OOTCW, the implications of these characteristics for desired capabilities and performance levels, and the adequacy of the current planning, research, development, and acquisition system's ability to engage in the technology push to address the needs of OOTCW.

Section 7.3 addresses operational challenges and capability shortfalls in OOTCW

Section 7.4 presents the panel's principal findings in these areas

Section 7.5 provides five key recommendations and describes 13 other recommendations

Section 7.6 provides conclusions

7.2 Implications of the Environment for Lethal Operations Other than Conventional War

From the standpoint of lethal effects, the foregoing suggests both the need for a high degree of precision in the use of lethal means for OOTCW and an environment in which survivability in many cases can outweigh military effectiveness in importance. Each will be briefly discussed.

7.2.1 Precision

The current environment increases the need for five types of precision:

- **Precise Target Information in Three Dimensions.** Future targets could include individual rooms, either in a multistory apartment building or in a deeply buried bunker. The possibility of such targets leads to a need for precise targeting in three dimensions—geolocation and elevation.
- **Precise Timing.** Hitting smaller targets may lead to a need for more precise timing information so that the weapon is put on target at the precise moment that is required to realize the desired effects. For example, it is easy to imagine that the probability of a successful attack on a terrorist cell would be greatly enhanced if the attack could be cued by real-time intelligence that indicates the terrorists' presence at a specific location.
- **Precise Delivery.** A more precise means of delivering weapons will enable targeters and warfighters to exploit more precise targeting information, even to the extent that they will be able to consider specific aim points on which a target should be attacked.
- **Precise, Tailored Effects.** Precise, tailored weapons effects will allow warfighters to exploit the other forms of precision by enabling real-time tailoring of precise weapons effects to specific targets—both in terms of geometry and fragmentation pattern.
- **Precise, Rapid Effects Assessment.** The effectiveness and efficiency of OOTCW will be greatly enhanced by precise, real-time assessment of effects, including battle damage assessment (BDA) or other forms of combat assessment.

[1] A full list of panel meetings is provided in Appendix 7B.

7.2.2 Survivability vs. Effectiveness

Recent experience—particularly the U.S. air campaign in Yugoslavia, in which U.S. casualties were kept to a minimum through a prolonged air campaign and the forswearing of ground combat forces—suggests that policymakers are giving higher priority to survivability (that is, minimizing casualties) than to the effectiveness or efficiency of military operations. To the extent that policymakers are willing to relax time constraints to better assure casualty minimization, this may suggest the increased desirability of a number of new capabilities that enhance survivability.

7.3 Operational Challenges and Capability Shortfalls

The previous section describes the panel's views on the key environmental characteristics of OOTCW and the implications of these characteristics for the sorts of capabilities and performance levels that are desirable for lethal OOTCW. It also identified some characteristics of the current planning, research, development, and acquisition processes that may be limiting the amount of effort devoted to developing technology options that could greatly improve the performance of lethal aerospace power in OOTCW. In this chapter, the panel describes in greater detail the key operational challenges and capability shortfalls encountered in OOTCW.

7.3.1 Intelligence

In the area of intelligence, the following operational challenges and capability shortfalls were identified:

- Precise, timely intelligence regarding target location above or below ground, with details about construction, interior spaces, and equipment or stores
- Timely damage assessment, especially in building or bunker interiors, and for WMD storage sites
- Remote sensing of chemical and biological agents
- Detection of non-emitting threats such as TELs and non-emitting IADS

7.3.2 Attack

In the area of attack, the following operational challenges and capability shortfalls were identified:

- Ability to attack a variety of military targets (mobile, fixed, or buried) in areas where collateral damage or fratricide is unacceptable
- Capability to attack non-emitting radio frequency targets, for example, surface-to-air missile (SAM) launch systems
- Weapons and concepts to neutralize WMD without collateral effects
- An effective capability to defeat ballistic missiles and launchers in the prelaunch and boost phases
- Capability to defeat theater cruise missiles

7.3.3 No-Fly Zones

In the area of no-fly zones, attention should be given to

- Dramatically reducing demand for people and aircraft for no-fly zone surveillance
- Reduced demand for people in fighters for no-fly zone enforcement

7.3.4 Aircraft Survivability

In the area of aircraft survivability, the following challenges were identified:

- Positive identification of noncooperative targets (air and ground)
- Aircraft self-defense against infrared (IR) missiles
- Non-emitting passive navigation

7.3.5 Technology Push

In the area of technology push, the following issues were identified:

- User and acquisition community education and training
- Fiscally constrained acquisition

In the next section, the panel provides its findings regarding these operational challenges and capability shortfalls.

7.4 Findings

7.4.1 Intelligence

Increased Detail and Precision of Intelligence

In order to support precision strikes with the necessary lethal effects and without unacceptable levels of collateral effects, *there must be an significant increase in the level of detail and precision of intelligence information*. Information needs will increasingly include precise target location, precise information on the environment and surroundings of the target, details of the target interior, and the location of particular equipment, functions, or stores.

In the case of underground facilities, details of the underground layout will be needed along with details about the construction and materials used. Details about the electrical and electronic equipment are needed to facilitate an electronic attack, and detail about WMD storage (materials, storage conditions, and locations) is necessary to design an attack that results in low collateral damage.

In addition to all of this, knowledge of hostile capabilities along ingress routes will become more important to assure survivability or to maintain surprise. The detection of non-emitting threats is an especially important and challenging aspect of this problem. This allows an adversary to deny U.S. forces the use of low-altitude air space with just the threat of SAM capability—as was done in Yugoslavia.

The need for information poses great challenges for the collection and dissemination of intelligence information. New approaches to the intelligence processes will be required along with substantial technology development for data collection, processing, and communication. The Intelligence Panel will be addressing all these issues at some length. However, there are some innovative long-term technical possibilities for data collection.

The use of laser sensors for the long-range detection of chemical or biological agents in the atmosphere.

The sensing of chemical and biological warfare (CBW) agents from remote locations has many advantages, not the least of which is a more timely and effective application of lethal force for neutralization. There are existing efforts to detect CBW agents from distances of a few kilometers, and these should continue. Extending these ranges to tens and hundreds of kilometers is very challenging but

may be possible using high-energy laser interaction with the molecular and atomic species involved. The cross-section of interaction is low, and resonant wavelengths from the ultraviolet to the far infrared are probably necessary. But these wavelengths are becoming available in high-energy laser systems and eventually may be scaled to sufficient powers to allow detection ranges that permit application from satellite or high-altitude UAV platforms. However, it is likely that such applications may not be affordable if dedicated single-purpose systems are required, but rather should be considered as part of multipurpose sensor suites. Two such concepts have recently been proposed. An important adjunct to these concepts is the use of such sensors for BDA following an attack on a storage location to determine leakage into the atmosphere.

Consider a constellation of a few mirrors in low Earth orbit able to precisely point laser beams to designated areas on Earth. A ground station (or several) could then shine a laser to the nearest orbital mirror and reflect the beam to any point on Earth either directly (so-called single bounce) or through other relay optics. By keeping the laser system on the ground, essentially any wavelength, power, or waveform could be transmitted and reflected to and from any unobscured point on Earth. There are many applications of such a “virtual presence” capability, but one possibility is chemical and biological detection. After detection, other nearby sensors could detect locations for attack. Such a concept has been studied under the AFRL LOCAAS study just completed. Another possibility is a multifunction laser radar sensor suite on board a UCAV. Again, one of the functions could be chemical and biological weapon detection. A concept for such a sensor suite is now being considered under the AFRL “Directed Energy Application to Tactical Air Combat” (DE ATAC) study. These studies should identify enabling technologies to guide AFRL research programs.

The development of a micro-flyer UAV that could carry sensors inside its structures.

The feasibility of miniature flying robots has been discussed for many years, and in the past decade a number of programs have designed and constructed such flyers. This class of robots is distinguished from traditional model airplanes in that they would use quiet propulsion such as flapping wings rather than the noisy gasoline engines. They have been envisioned in sizes as large as a model airplane and as small as a bumblebee. In addition, some of these devices have been envisioned with the capability to land and move around (crawl) in confined spaces.

The majority of the work with DoD applications has been sponsored by the Defense Advanced Research Projects Agency (DARPA), and a variety of research organizations have participated. There have been successes in creating devices that can fly, but there is still considerable work to be done with range and endurance limits to make the devices militarily useful. The payload capability is also a limiting factor, but the continuing miniaturization of sensors will make more capabilities available for the micro-flyers.

Development of a wireless integrated network of Micro-Electro-Mechanical Systems (MEMS) sensors that can detect chemical and biological agents.

Methodologies for the detection and identification of hidden and passive systems require special technological development to meet these challenges. In peacetime, the detection and identification of chemical and biological agents require systems to determine the presence of these substances and to communicate their findings. Another complex issue is that of determining the locations of missile sites and launch facilities that are mobile but not emitting, making detection difficult.

A possible approach is to distribute MEMS devices over the area of concern. In these systems, MEMS sensors are integrated with low-power electronics and high-speed wireless communication and signal processing. These systems are characterized by being ultra-small and quite inexpensive. The systems are used to fuse the data collected by the sensors and to share it over the network to determine the presence of a substance or motion. These systems must be extremely reliable and have a low probability of false alarm, even if some elements fail. Also, in the presence of possible jamming, the system frequency

should be quite agile. Finally, the system should use high-density power systems such as fuel cells, scavenge energy (such as local vibrations, electromagnetic fields, and fluids), from the environment or have resonant circuits to receive directed energy.

These micro systems would be dispensed in large numbers and would be randomly distributed over the desired region. Constant monitoring of these systems could be performed by UAVs systematically following an efficient monitoring pattern.

Better Real-Time Damage Assessment

Finally, there is an increasing need for *better damage assessment, including real-time assessment* in some cases. The information needed can be stated in hierarchical order as follows:

1. Where did the weapon strike?
2. For an earth penetrator, where did the weapon go underground?
3. Did the weapon function as described?
4. What were the effects of the attack?
5. For a chemical or biological attack, did any agent escape?

There is little technology available for most of the tasks identified above, and this offers a significant challenge to intelligence. Some technologies promise some ability to provide some of this information. They fall into two categories—sensors that accompany the weapon, and off-board sensors.

Robust sensors that accompany the weapon can include imaging sensors or geolocation sensors with a trailing wire for transmission or a detachable sensor that remains on the surface. Off-board sensors can include sensors on a following weapon, on a UAV with sensors, unattended ground sensors, or a remote laser to detect agent escape.

7.4.2 Target Attack

Delivery Methods Are Needed to Precisely Place Munitions in Order to Defeat Deeply Buried and Hardened Targets. This Means Getting the Munitions Into the Right Room.

It has long been a goal of targeting to be able to penetrate underground targets. Today the use of underground shelters is primarily two-fold: (1) To house C^2 facilities and personnel or (2) to protect highly valuable weapons such as WMD or aircraft. These may be deeply buried or shallow. Typically, there will be underground structures consisting of many rooms or many floors separated by reinforced concrete. Penetration of these bunkers can be formidable. Penetration must occur not only to the right level but also to the right location (room) on that level, and munitions be activated only when at that location. Such three-dimensional precision has only recently been achievable as a product of precision guidance and smart fusing. It is obviously important to first have the intelligence information to know the precise location of the target (see 7.4.1, “Intelligence”).

There are depths beyond which penetration is not possible. Penetrator techniques normally involve at least two stages: (1) penetration by increased velocity (kinetic energy), which may be either the result of delivery velocity or aided by some propulsion technique and (2) detonation of the warhead after the right location is reached (smart fusing). Penetration and fusing to within a few meters of the desired target location will continue to be extremely challenging and will require continued research on smarter fuses and other penetration technology.

Contained Neutralization of Chemical and Biological Agents

The proliferation of WMD has been a fact of the post–Cold War era and is likely to continue. This circumstance has driven active and passive preparation to cope with these capabilities in case the United States ever becomes involved in war with any nation or transnational actor with WMD capabilities.

However, the lethal use of air power may also be a part of a counterproliferation strategy in circumstances less than war. The current capabilities for carrying out such missions without unacceptable, collateral damage are very limited.

A hostile capability for the use of a weapon of mass destruction must include means of production, transport, storage, and a delivery system. Parts of these operations may be conducted clandestinely and may involve facilities that are hardened or deeply buried to protect against attack. In addition, the materials or agents involved may be very difficult to destroy and may be very toxic if allowed to escape into the environment.

The delivery systems can be dual-capable and are often mobile and hard to detect and track. These systems are explicitly addressed under the panel's discussion of mobile targets (Section 7.4.2.4).

For this section, we have focused on the lethal attack of storage facilities for chemical and biological weapons. This is an especially challenging task because of the potential for releasing these agents as a result of the attack. Given the weapon capabilities available today, the specter of these collateral effects has deterred any such attacks to date.

The technology dilemma of attacking such storage facilities has three components. First is the need for precise and detailed information about the storage location, the location of the warheads or storage containers to be attacked, and the precise configuration and construction of the containers themselves. Second is the need to be able to deliver an offensive weapon to a precise location in this storage facility. Third is the need for a lethal capability in that weapon against the agents as they are stored. The three components are summarized as follows:

- The intelligence needs are formidable, and the technology to obtain such information must continue to get high priority. These needs are discussed more extensively in Chapter 4.
- The precision delivery of a capable warhead to a precise point in a hardened and buried facility has also been receiving considerable attention. Again, there are two parts to this problem. The first is the precision delivery to a point on the surface; the second is the precision delivery of the lethal action in the underground target.
  - For precision delivery to a point on the surface, the technical problem is similar to that for other precision weapons. Very high precision is required. Ongoing programs are addressing these problems.
  - The penetration into the facility to a precision location is more challenging. An underground geolocation system for a penetrating warhead does not exist yet. A void-sensing fuse developed at the Weapons Directorate of AFRL has been successfully tested. This fuse can sense the deceleration of the penetrating warhead and recognize when the warhead moves from a high-density region to a low-density region. It is clear that precise knowledge of the target is required and that there can be no unknown voids that can deceive the fuse.
- The third aspect is the lethality against the stored agent. This lethality can be defined in terms of the outright neutralization (destruction) of the agent or in denying access to the warheads or stored agent for some period of time.

The neutralization of chemical and biological agents is the real goal. However, most of these agents are so toxic that the consequences of the escape of even a relatively small quantity into the surrounding environment is a major issue. This consequence proved to be a deterrent to attack even in Desert Storm.

These considerations have led to programs addressing access denial as a specific goal of an attack on a storage facility. The more classical effects of a conventional weapon attack such as closing entrances or collapsing rooms require precise intelligence about the storage circumstances and precise placement of the attacking weapon, or there may be a risk of breaching the containment of the agent and of collateral effects. This risk has led to other technical approaches to denial such as filling the room with "sticky foam"—a substance that is very hard and messy to remove. A foam has been demonstrated, and it offers delay with far less risk of unacceptable collateral effects.

Many chemical and biological agents cannot be destroyed by the detonation of a highly explosive warhead. In addition, the details of the containment of the agent and the precise geometry of the containers relative to the warhead at the time of detonation are critically important in determining the effects. If the agents are contained in warheads (or any relatively small rugged containers), failure to breach the container may protect the agent, whereas breaching it may result in dispersal.

Other possible kill mechanisms for various agents include heat, radiation, and ultrasonics. All of these have been studied, and a variety of attack weapon concepts have been explored in programs. The best summary of all these activities that the panel found was a study conducted by the Directorate of Nuclear and Counter-Proliferations (AF/XON).

The results of the study make clear that while there are means to neutralize small exposed quantities of chemical or biological agents, no existing weapon can successfully neutralize agents in bulk or warhead storage and, at the same time, assure no external collateral effects. The results also suggest that the destruction mechanism most likely to achieve these objectives is heat, which will not damage the container or warhead the agent is stored in. However, the robustness of some of the biological agents requires very high temperatures over long periods. An innovative high-intensity heat source was briefed to our study. We recommend this should be pursued.

Tailored, Focused Effects on Fixed and Mobile Targets

The destruction of specific targets with minimal collateral damage will continue to be an important part of OOTCW. Hence smaller, more precise smart bombs should be developed to tailor the lethality and precision to the intended target. Initial capability has been demonstrated in the SSB, which currently weighs 250 lb. It is intended for either shallow penetration or surface targets and can be carried either internally or externally.

For mobile targets, adaptive multimode warheads should be developed. Tailoring of the blast and fragment warhead effects should be adaptive in flight, based on identification of the target. Initial capability is being demonstrated in LOCAAS, which—if successful—should be transitioned into development.

The fusing and fire control of munitions must adapt the lethality footprint of the munitions to maximize damage to the target. This involves not only knowing and precisely hitting the aimpoint, but also knowing the relation of the aimpoint to the most vulnerable aspect of the target. This would allow picking the aimpoints that are easier to detect and track and would allow focusing the blast and fragmentation to vulnerable areas.

A worthwhile goal is to reduce the types and sizes of munitions an aircraft must carry by increasing the flexibility and adaptability of munitions to kill many targets. This would allow increased loadout and more kills per sortie.

Striking Non-Emitting Mobile Targets

The primary problem of striking non-emitting mobile targets is the detection and identification of targets such as SAM and theater ballistic missile (TBM) launchers, which can quickly move and launch their missiles. Munitions (such as LOCAAS, discussed above) to quickly and effectively strike such targets should be demonstrated and developed. OOTCW should emphasize SAM launchers, since survival of aircrews is paramount, and TBMs are perhaps less likely to be employed. Real-time detection and tracking of these targets is necessary if a strike is to be successful. Advanced sensor suites such as Laser Imaging Detection and Ranging (LIDAR) and synthetic aperture radar (SAR) are being examined for detecting TBM launchers.

Kill (Disable) Equipment and Vehicles With Directed Energy

High-power microwave (HPM) beams interact with matter to generate heat (as in microwave ovens). Microwaves also interact with electronic devices to cause interruptions, spurious signals, disablement, or destruction. The effects can be non-lethal or lethal. Non-lethal applications are discussed in the Non-Lethal Effects Panel report. Lethality means the permanent disablement of an electronic function so that it can no longer be used for its intended purpose. There is now reasonable understanding of this interaction as a result of recent research. As electromagnetic radiation, HPM propagates at the speed of light and penetrates most adverse weather conditions. Although recent progress is evident, it remains a challenge to generate HPM and to radiate the beams in militarily useful volumes, weights, and antenna apertures.

Several concepts are being studied under an AFRL study, DE ATAC. These are (1) large aircraft defense, (2) small aircraft defense, (3) electronic kill by UCAV, and (4) enhanced precision-guided munitions. The purpose of these studies is to identify and focus the AFRL programs to provide enabling technologies such as very high-power electric generation on aircraft.

Theater Ballistic Missile Defense

Considerable effort has gone into research on defeating TBM ever since Desert Storm. Current concepts involve multiple tiers of engagement (perhaps four or five). The Air Force is addressing the two earliest tiers, prelaunch (attack operations) and boost-phase intercept (BPI) of the launched missile. These first two tiers are critically important for several reasons, but most obviously because they are the only way to preclude multiple submunitions from being dispensed and may be the only way to effectively defend against TBM-delivered WMD. Even in OOTCW, one cannot preclude a rogue nation from launching a TBM attack.

In BPI, the time available to attack the booster is very short (about 100 seconds). If a defended radius of several hundred kilometers is needed, this places extremely high demands on kinetic energy missile interceptors, which makes them a less viable solution. Directed energy (at the speed of light) is being actively pursued through the airborne laser (ABL) program, which will demonstrate a large laser (>1 MW) on a large aircraft (a 747–400) flying at about 40,000 feet. It will detect, track, and destroy TBMs in boost phase at several hundred kilometers from the ABL. The SAB continues to find this the most effective boost-phase intercept concept, and it is scheduled for demonstration in 2003. The space-based laser, which is based on satellites, has similar features, with the advantage of being able to attack at much longer ranges. This program, using more advanced technology, is not likely to be demonstrated until after 2010.

Attack operations (that is, attacking prelaunch) are primarily limited by the inability to detect the launcher (TEL) before it launches the missile. Timeframes are short but are many minutes in duration from the time a TEL is in final position until launch occurs. There are several munitions (such as direct attack and standoff) that could kill a TEL once it is identified. However, if significant standoff is required

(> 100 km), high-speed missiles will also be required. An alternative or adjunct concept is to determine launcher location after the first missile is fired (and perhaps destroyed by ABL or later tiers) and then to try to destroy the launcher so that it cannot be used again. Since missile/launcher ratios may be 10:1, this may be an effective attrition strategy.

Theater Cruise Missile Defense

Attacking cruise missiles is a formidable task. Historically emphasis has been placed on attacking the launchers (that is, aircraft, TELs, and ships). However, especially in OOTCW, launch means and locations may not be known, so the ability to attack cruise missiles in flight will become increasingly important. The most challenging problem is the detection and tracking of low-altitude cruise missiles because of clutter and because of their ability to hide behind terrain. A robust solution to detection with acceptably low false alarm rates continues to be the first priority. Currently the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System is using over-the-horizon sensor systems to detect land attack cruise missiles.

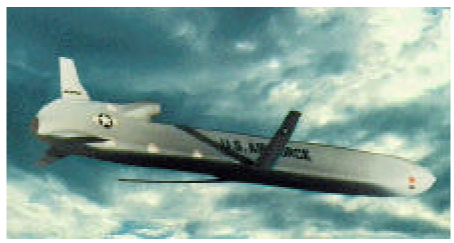

Figure 7-1. *Air-Launched Cruise Missile*

- If detection and tracking become practical, then attacking the cruise missile could potentially be achieved in a number of ways. Air-to-air missiles (such as the advanced medium-range air-to-air missile) are being evaluated to attack cruise missiles. A revolutionary approach would be the use of a high-energy laser beam to destroy the cruise missile. At least two concepts have been examined. The ABL flying at 40,000 feet could place lethal energy on the cruise missile from more than 50 kilometers. There are at least two limitations in this look down–shoot down scenario: (1) clear line-of-sight to the target and (2) the ability to track the cruise missile in the IR spectrum accurately enough to hold the laser beam precisely on the target.
- A second approach is the new Airborne Tactical Laser (ATL) concept, which could fly at any altitude and have a lethal range of about 20 kilometers. With such a range, the most practical application would be defending high-value targets (such as ships, control and reporting centers, air operations centers, and airfields).

7.4.3 No-Fly Zones

No-fly zones such as those established for Northern and Southern Watch in Iraq are causing significant problems for the Air Force. Ground-threat environments and long sortie durations require large numbers of support aircraft such as tankers, the Airborne Warning and Control System (AWACS), Rivet Joint, suppression of enemy air defenses (SEAD), and electronic warfare (EW) platforms. The high tempo involved in such operations is wearing out personnel and airframes. High manpower requirements relate directly to the extremely high costs of maintaining no-fly zones that support U.S. policy. UAVs (unarmed) and UCAVs (armed) offer capabilities that may replace and/or augment many of the assets required for no-fly zone implementation while significantly reducing costs. Examples of such capabilities include

- Long-dwell (Global Hawk–type) UAVs with flexible plug-and-play sensor suites that provide AWACS, Joint Surveillance, Target, and Attack Radar System (JointSTARS), EC-130, and Rivet Joint–like capabilities
- UCAVs equipped with directed-energy weapons such as the ATL that provide kill capability against ground and airborne targets, including theater cruise missiles

UAVs and UCAVs

Current R&D efforts focus on UAVs and UCAVs as stealthy, Global Hawk–like "trucks" with long range and long endurance, carrying small, highly sophisticated packages of equipment and weapons that enable them to perform across the entire spectrum of Air Force missions with both autonomous and reachback capabilities. The requirements for such systems include

- Long endurance
- AWACS, JointSTARS, EC-130, and Rivet Joint–like capabilities
- Lethal SEAD
- Autonomous operations
- ATL for attack of ground and air targets
- Small munitions and submunitions for attack
- Secure long-range communications with wide bandwidths for C^2

UAVs and UCAVs, when combined with space systems, increased computing power, and secure communications, *and when operating seamlessly with manned systems*, offer great possibilities for enhancing future warfighting capabilities. It is possible to envision robust squadrons of UAVs and UCAVs operating from mother ships or reachback control centers, equipped with artificial intelligence, intermingled with manned aircraft and space systems, and providing persistent presence for intelligence, surveillance, and reconnaissance (ISR), communications relay, SEAD, EW, and precision strike to the warfighter within the next 25 years. The major advantages enjoyed by UAVs and UCAVs are persistence, reduced life-cycle costs, and decreased personnel requirements.

7.4.4 Aircraft Self-Protection

Significant improvements may be required for aircraft survivability and self-protection. Identification of noncooperative targets, both air and ground, defenses against IR missiles (air-to-air and ground-to-air), and nonemitting navigation modes appear to be important future requirements.

Identification of Noncooperative Targets

Positive ID of both air and ground targets by both manned and unmanned systems is feasible. Such capabilities require high-speed computers that apply artificial intelligence to acquire and assess signatures and to attack targets in accordance with preprogrammed rules of engagement. Wideband, secure, long-range communications will be required for reachback and C^2.

Aircraft Defense Against IR Missiles

Better defenses against an increasingly sophisticated IR missile threat will be required. This likely includes more sophisticated flares, mechanisms that spoof IR missiles after launch, and others that prevent their firing from launch rails.

Non-Emitting Navigation

Passive, non-emitting Global Positioning System (GPS) navigation is becoming standard in most aircraft; however, some missions—such as low-level, night, all-weather navigation—currently use radar for terrain-following/terrain-avoidance. These radar emissions may permit detection at extended ranges. It may be possible to replace radar with a safe detection-avoidance navigation system that eliminates or reduces radar emissions. In addition, threat-avoidance navigation (TAN) is a current Special Operations Forces requirement. Several technologies appear to offer promise:

- Technologies that use narrow pulse to replace current radar emissions to achieve low probability of intercept may greatly reduce the likelihood of detection
- Active radar may also be replaced by a system using GPS augmented with accurate topological maps constructed from laser satellite images that are further augmented by highly accurate worldwide Digital Terrain Elevation Database (DTED) level III data
- TAN requires wideband, secure data and communications links to transmit current threat updates

Both approaches for reducing radar emissions should be pursued. Wideband, secure data and communications links that permit long-range threat updates are a must.

7.5 Recommendations

The Lethal Effects Panel had a total of 19 recommendations, 6 of which constitute key recommendations, with the other 13 being further recommendations.

7.5.1 Key Recommendations

Develop Air-Deliverable Lethal Miniature Munitions

The panel recommends that the Air Force develop a family of autonomous miniature munitions to enable tailored lethal effects on fixed and mobile targets.

- For mobile and relocatable targets, complete the development of LOCAAS
  - Accelerate the demonstration and EMD
- For buried or fixed surface targets, complete the development of the SSB
  - Accelerate into EMD

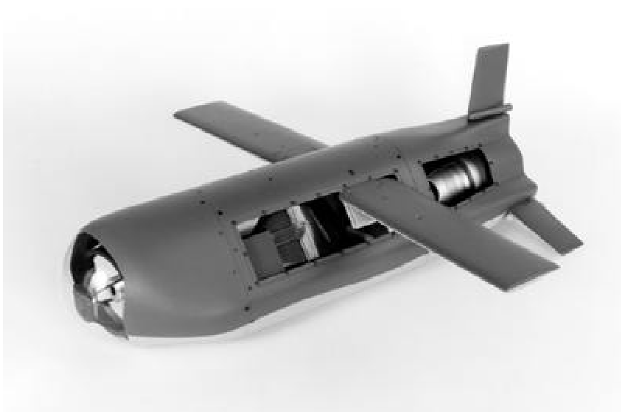

Figure 7-2. *LOCAAS*

Develop Long-Dwell UAVs to Replace LDHD Assets in No-Fly Zones

The panel recommends developing a robust UAV-based remote-sensing capability for no-fly zone air surveillance.

- In the short term, develop Global Hawk with the appropriate sensor and C^2 connectivity to a theater ground station
- In the longer term, connectivity should be extended to any location

Figure 7-3. *Global Hawk*

Develop Capabilities for Attack of Chemical or Biological Weapon Capabilities

The panel recommends that the Air Force develop a capability for neutralizing chemical and biological agents in bunker storage situations, without causing dispersal of the target agent or causing undue collateral damage. This requires a technology initiative with the following aspects:

- Precise intelligence regarding storage location in three dimensions
- Precision delivery of the attacking capability
- R&D of an intense heat source

Intensify Research in Noncooperative Target Identification

The panel recommends a broad program of R&D to generate capabilities to positively identify noncooperative air and ground targets.

- Pursue a broad-based series of research efforts to include tagging systems, multispectral or hyperspectral signal processing, and forensic signal-processing algorithms
- Develop a database of nonstandard target signatures to enable signature processing and evaluation of candidate solutions
- Develop a high-fidelity recorder to capture RWR signals to allow additional correlation of targets for battle management

Develop a UCAV for Mobile Target Attack

The panel recommends developing a long-dwell autonomous capability (that is, a "long-dwell LOCAAS").to detect, locate, target, and strike hard-to-find mobile targets such as TELs and non-emitting IADS

- Demonstrate the launch of a LOCAAS from a UCAV vehicle

7.5.2 Further Recommendations

The panel has an additional 13 recommendations, listed below.

1. The Air Force should continue to support the DARPA program in miniature and micro UAV experiments and to ensure that the program is directed toward a capability for the delivery of small sensors to places that are difficult to get to otherwise—such as the inside of a building or underground bunker.

2. The Air Force should begin a long-term research effort to develop MEMS as sensor-carrying devices to be a part of an integrated wireless network and to be used to detect chemical or biological agents.

3. The Air Force should increase the research on technology (such as trailing-wire cameras, robust sensors, ejectable sensors, and millimeter-wave damage characterization devices for real-time BDA).

4. The Air Force should continue to support Air Force and Defense Threat Reduction Agency earth penetrator programs to defeat deeply buried and hardened targets.

5. The Air Force should increase the participation and support of programs focusing on the basic science and understanding of neutralizing chemical and biological agents.

6. The Air Force should extend the adaptive warhead capability of a LOCAAS-type weapon with sensor and fusing to identify the most vulnerable part of the target and to enhance the fragment pattern and direction. The goal is a highly destructive weapon with very low collateral effects.

7. The Air Force should pursue LIDAR and SAR for TBM launcher detection and for the potential detection of non-emitting SAM components.

8. The Air Force should design and conduct a demonstration of an HPM system designed to kill and/or disable equipment and vehicles.

9. The Air Force should continue support for the ABL as a boost-phase TBMD system.

10. The Air Force should join with the Marine Corps in supporting the ATL as a TCMD system. The ATL should also be examined for its potential in other applications such as the enforcement of no-fly zones.

11. The Air Force should accelerate the development of a worldwide DTED database so that emitter-free low-level navigation will become possible.

12. The Air Force should accelerate the current infrared countermeasures (IRCM) R&D activities. The Air Force should also expand the program to include protection of UAVs and UCAVs.

13. The Air Force should continue the research of remote sensing of chemical and biological warfare agents from aircraft, and the ground-based, space-reflected laser concept.

7.6 Conclusions

The Lethal Effects Panel has sought to focus its analyses, findings, and recommendations on areas that are critical to the Air Force and to the nation

- The panel's focus on air-deliverable lethal miniature munitions addresses the heightened requirement in OOTCW for precision and tailored effects, while providing opportunities to dramatically increase the number of kills per sortie.
- The focus on improved capabilities for detecting, locating, targeting, and destroying WMD without collateral damage, particularly when WMD are in deeply buried bunkers, addresses a critical challenge in the future counterproliferation OOTCW that also may be encountered in the context of an MTW.
- The focus on long-dwell UAVs, UCAVs, and LOCAAS points to a family of solutions both for reducing the high operational tempo and personnel tempo costs that are being incurred in the enforcement of no-fly zones and for providing more effective capabilities for detecting, locating, targeting and destroying hard-to-find, non-emitting mobile targets, such as TELs and IADS.
- The focus on noncooperative threat recognition addresses both the heightened concerns about aircraft survivability that arise in OOTCW, and the difficulties inherent in detecting, locating, and targeting adversary systems encountered in OOTCW, including adversary aircraft and small, mobile targets.
- The focus on improving the technology push for OOTCW-relevant capabilities addresses the need to improve the Air Force's process for developing revolutionary technology breakthroughs that can provide the precision, survivability, and other performance characteristics of aerospace power needed in an OOTCW setting and that can provide forces more suitable to the tight constraints (for example, on friendly casualties and collateral damage) frequently imposed on aerospace operations.

Although OOTCW are likely to continue to pose unique and substantial challenges to the effective conduct of lethal airpower operations, the panel feels that its recommendations go a long way toward addressing many of the core problems that will be faced by Air Force aerospace power in future OOTCW.

Appendix 7A

Lethal Effects Mission Statement

The charter for the Lethal Effects Panel in identifying technologies to leverage aerospace power in OOTCW was as follows:

- Identify concepts of operation and lethal weapons, delivery systems, operations, and tactics needs and issues unique to OOTCW
- Assess current and planned Air Force capabilities against these needs and the staff-provided OOTCW vignettes
- Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
- Postulate evolutionary and revolutionary concepts options (materiel and tactics) and technologies for meeting these needs
- Consider operations such as maintaining peace (separation of combatants), no-fly zone maintenance, border or area management or denial, surgical operations, and attacks on leadership
- Consider lethal weapons delivered from all types of platforms (manned aircraft, UCAVs, space vehicles, etc.), their operational employment, and their effects
- Identify means for selecting and assuring precise target effects
- Interface and coordinate closely with the Non-Lethal Effects Panel (especially with regard to delivery and application of non-lethal effects)

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Appendix 7B
Organizations Consulted

Air Combat Command

Air Force Research Laboratory

Air Force Special Operations Command

Air Land Sea Applications Center

Ballistic Missile Defense Organization

Defense Advanced Research Projects Agency

U.S. Atlantic Command (now called U.S. Joint Forces Command)

U.S. Central Command

U.S. Southern Command

U.S. Special Operations Command

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Appendix 7C
UCAVs In OOTCW

7.C.0 Introduction

The subject of unarmed UAVs and armed UCAVs has long been an area of study and R&D within the Air Force. Operational interest began in World War II. Early systems (starting in Vietnam) were used with varying degrees of reliability. UAVs and UCAVs have also been used extensively in the drug war in Central and South America, by the Israelis in the Middle East, and by allied forces during the Gulf War. Most recently, both the Army and Air Force have employed UAVs extensively in Bosnia and Kosovo in ISR roles.

UAVs and UCAVs were singled out in the New World Vistas study as "having considerable promise for both combat and support missions."[2] That report strongly urged the Air Force to "field UAVs to gain major new warfighting capabilities" and to "develop operational concepts and operational priorities to exploit UAV technology."[3] Since publication of *New World Vistas*, the leadership of the Air Force has embraced the concept of continuing to develop UAVs and UCAVs in an "evolutionary versus revolutionary" manner and has enlarged the concept to employ UAVs not only for ISR but for communications relay, and UCAVs for lethal SEAD and strike operations.

7.C.1 A History of Limitations

Early UAVs suffered from a lack of adequate technology. The design of unmanned platforms was hampered by the lack of adequate computer power and communications links to employ and command and control unmanned vehicles. The capabilities of manned aircraft and weapons technology far surpassed the capabilities and utility of unmanned systems. The rapid emergence of space-age and modern computer technology, particularly the advent of stealth and high-speed computers, has given UAVs and UCAVs new life as useful concepts for warfare.

Current UAV and UCAV limitations center not on technology, but on insufficient funding of R&D because of decreasing budgets. Given adequate funding, UAVs and UCAVs can significantly enhance the warfighting capability of and "augment and complement" (rather than replace) manned systems. Early on, the development of UCAVs envisioned hypersonic vehicles that were able to pull 10 to 12 gs, performing missions such as air superiority in fashions beyond the capability of manned aircraft. Such concepts were extremely expensive.

Current development focuses on UAVs and UCAVs as "trucks" with long range and long endurance, carrying small, highly sophisticated plug-and-play packages of equipment and weapons that enable them to perform across the entire spectrum of Air Force missions.

UAVs and UCAVs that can operate in the same manner as manned systems are still far in the future, except for a limited number of dedicated missions, such as communications relay and ISR. The ability of unmanned systems to "think on the run" (liked manned systems) with artificial intelligence is at least 10 years away.

Two other significant challenges facing UAVs and UCAVs are the integration of manned and unmanned systems into the same airspace and the availability of secure communications links over long distances.

[2] *New World Vistas*, SAB Study, 1995.
[3] Ibid.

Both of these are enormous problems that must be solved to maximize the capabilities of the UAV and UCAV. Solving these problems at current R&D budget levels will take at least 15 years.

The major issues and limitations facing UAVs and UCAVs appear to be

- R&D funding
- Complexity of C^2
- Agreed-upon concepts of operations
- Reliability of long-range, secure data and communications links
- Survivability
- Affordability of tradeoff decisions versus manned systems

7.C.2 Near-Term and Far-Term Uses

Although significant limitations appear to hamper the full employment of UAVs and UCAVs in the next 10 to 15 years, the future appears much brighter when the horizon is expanded to 25 years.

- Current systems such as the Predator and Hunter are reliably passing ISR information, including real-time video.
- In 3 to 5 years the advanced development of reliable links between manned and unmanned systems will be possible over short distances. This sets the stage for “mother ship operations” (a fighter controlling three to four UCAVs) 10 to 15 years from now.
- Robust, secure, high-data-rate ISR and communications relay platforms are envisioned as realistic by 2007.
- SEAD (lethal and non-lethal) UCAVs are envisioned as being realistic by 2015.
- In 20 years, operational concepts including 20 to 30 UCAVs performing different roles along with manned platforms are possible.
- In 25 years computer and communication technology should allow real-time (versus preplanned) flight control of large numbers of UCAVs and manned platforms in the same airspace.

7.C.3 The Challenges for UAVs and UCAVs

The recent air warfare experience in Kosovo has demonstrated one crying, unfulfilled need that UAVs/UCAVs can solve; *persistence*.

The warfighter needs a persistent system that can loiter, gather and process information, and attack targets while surviving in a modern IADS. The keys to UAV and UCAV success in this role as seen by warfighters are

- A long-range, long-endurance, stealthy platform
- Secure data and communications links
- Low life-cycle costs (75 percent lower than manned systems)
- Small footprint for mobility
- High-speed computers for artificial intelligence
- Small, accurate munitions
- Interoperability with manned systems

- Reliability equal to or greater than manned platforms

All of these keys to success appear achievable within the next 25 years within projected budgets. Increased R&D or unforeseen breakthroughs in technology may make acceleration of UAV and UCAV integration into modern warfare possible.

7.C.4 Special Uses of UAVs and UCAVs

Other special UAV and UCAV uses are possible:

- Artificial intelligence may permit programming of varied electronic and hyperspectral target signatures that can be seen and attacked by a long-endurance, loitering UCAV carrying large numbers of small munitions and submunitions
- UCAVs are being examined for the theater missile defense role. This concept includes loitering UCAVs armed with intercept weapons (perhaps ATL) that attack TBMs in the boost phase
- Miniature (6-inch) UAVs and UCAVs are possible that travel short distances to provide short-range reconnaissance and warning for such threats as chemical and biological weapons
- Miniaturization of components greatly expands UAV and UCAV possibilities

7.C.5 Conclusions

UAVs and UCAVs, when combined with space systems, increase computing power, and long-range secure communications, and when operating seamlessly with manned systems, offer possibilities to dramatically enhance warfighting capabilities. It is possible to envision robust squadrons of UAVs and UCAVs, operating from mother ships or reachback control centers, equipped with artificial intelligence and intermingled with manned aircraft and space systems, and providing persistent presence for ISR, communications relay, SEAD, EW, and precision strike to the warfighter within the next 25 years. The major advantages enjoyed by UAVs and UCAVs are persistence, reduced life-cycle costs, and reduced personnel demands.

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Appendix 7D

Lethal Effects Panel Traceability Matrix

Italicized entries connote recommendations that address multiple findings

OPERATIONAL CHALLENGES/ CAPABILITY SHORTFALLS	FINDINGS	RECOMMENDATIONS
7.3.1 INTELLIGENCE	7.4.1.1 Increased detail and precision	*7.5.1 Chemical/biological*
	7.4.1.2 Better BDA	7.5.2, #3 Real-time BDA
7.3.2 ATTACK	7.4.2.1 Deeply buried	*7.5.1 Chemical/biological*
		7.5.2, #4 Earth penetrators
		7.5.2, #5 Neutralize chem/bio
	7.4.2.2 Chemical/biological	*7.5.1 Chemical/biological*
		7.5.2, #2 New sensors
		7.5.2, #4 Earth penetrators
		7.5.2, #5 Neutralize chem/bio
		7.5.2, #13 Ground-based/space reflect laser-chemical/biological detect
		7.5.2, #1 Mini-micro UAVs
	7.4.2.3 Tailored effects	7.5.1 Air-delivered lethal mini-weapons
		7.5.2, #6 Adaptive effects weapons
	7.4.2.4 Mobile targets	*7.5.2, #8 HPM for vehicles*
		7.5.1 Long-dwell UAVs
		7.5.1 Increased research noncooperative target ID
		7.5.1 UCAV for mobile attack
		7.5.2, #7 LIDAR for TBM detection
	7.4.2.5 HPM	*7.5.2, #8 HPM for vehicles*
	7.4.2.6 TBM	*7.5.1 Long-dwell UAVs*
		7.5.2, #7 LIDAR for TBM detection
		7.5.2, #9 ABL
	7.4.2.7 TCMD	*7.5.2, #9 ABL*
		7.5.2, #10 ATL
7.3.3 NO-FLY	7.4.3.1 UAVs and UCAVs	*7.5.1 Long-dwell UAVs*
		7.5.1 UCAV for mobile attack
		7.5.2, #1 Mini-micro UAVs
		7.5.2, #10 ATL
		7.5.2, #12 IRCM and protect UAVs
7.3.4 AIRCRAFT SURVIVABILITY	7.4.4.1 Noncooperative target recognition	*7.5.1 Long-dwell UAVs*
		7.5.1 Increased research noncooperative target ID
		7.5.2, #13 Ground based/space reflect laser-chem/bio detect
	7.4.4.2 Defense against IR missiles	*7.5.2, #12 IRCM and protect UAVs*
	7.4.4.3 Non-emitting navigation	*7.5.2, #11 DTED*
7.3.5 TECHNOLOGY PUSH	3.8 Technology base flexibility for OOTCW needs	*3.8 Technology base flexibility for OOTCW needs*

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Chapter 8
Force Management

8.0 Introduction

This report contains the findings and recommendations of the Force Management Panel of the Scientific Advisory Board (SAB) study on Technology Options to Leverage Aerospace Power (TLAP) in Operations Other Than Conventional War (OOTCW). The focus of this panel was the evaluation of force management and communication needs within the charter of the TLAP study. Specifically, the terms of reference for the Force Management Panel were:

1. Identify mission planning and command, control, communications, and computers (C^4) needs and issues unique to OOTCW
2. Assess current and planned Air Force capabilities against these needs and the staff-provided OOTCW vignettes
3. Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
4. Postulate evolutionary and revolutionary concepts (materiel and tactics) and technologies for meeting these needs
5. Determine needed changes in structure or organization
6. Interface and coordinate closely with the Intelligence and Vigilance (I&V) Panel
7. Provide the primary interface between the TLAP study and the Battlespace InfoSphere Ad Hoc study

The work of the panel focused primarily on tasks 1, 3, 4, and 5. There was close coordination throughout the study with the I&V Panel (Task 6). Members of each panel participated in the visits and briefings of the other panel, held joint sessions, and coordinated relevant findings and recommendations.

The concurrent development of the Battlespace InfoSphere study under the chairmanship of Gen McCarthy warranted narrowing the scope of the Force Management Panel's study, since the broad issues of command and control (C^2) and technologies for the collection, fusion, and presentation of information were being addressed by that study (Task 7).

The Force Management Panel approached the study by visiting and collecting information from a cross section of organizations both within and outside the Air Force. The panel used a matrix approach in selecting and organizing the visits: one dimension of the matrix was the set of functions that make up force management; the second dimension was the type of organization: operators and users, agencies and centers, and research and development (R&D) organizations. The objective of the visits was to cover as many functions as possible to develop a notional representation of force management at one or more levels. Visits specifically focused on discussions rather than formal briefings and ranged from lengthy discussions with senior leadership to visits with operators in wing command centers. The list of organizations visited is presented in Appendix 8B.

An additional task of the panel was to examine defensive information warfare (IW) and information assurance. This task was to be done in coordination with the Non-Lethal Effects Panel that was to examine offensive IW. The panel did address this issue at length from the basic research level to current operations. The findings and recommendations regarding this area are not included in this report; they are part of an overarching, study-wide recommendation that appears in Volume 1.

8.0.1 Environment

According to Gen Michael E. Ryan, Air Force Chief of Staff, the Expeditionary Aerospace Force (EAF) concept provides three key things for the Air Force, warfighting commanders, and the nation:[1] First, the EAF provides a known rapid-response capability tailored to support a wide range of contingencies. This is important because, since the end of the Cold War, contingency operations have increased fourfold. Second, the EAF provides predictability and stability across the force, improving morale and retention. This is achieved through a schedule of rotations allowing Air Force personnel to plan for deployments. Third, the EAF provides further integration of the active, Guard, Reserve, and civilian forces.

The EAF organizationally links forces in geographically separated units into standing Aerospace Expeditionary Forces (AEFs). Communication through networks allows the coordination of dispersed groups that is needed to provide the envisioned responsive, deployable combat power. Communication within an AEF requires Global Grid access to support joint, distributed operations in a collaborative environment with reachback support.

Traditionally, the Air Force has focused—and rightfully so—on organizing, training, and equipping aerospace forces to destroy targets and evade threats in military scenarios. To meet these military requirements, the Air Force uses an *ad hoc* "kill chain" of intelligence, surveillance, and reconnaissance (ISR), C^2, and strike platforms. The kill chain is *ad hoc* in that it is not the result of a single, deliberate mission needs statement, operational requirements document, or acquisition program.

Given the increasing proliferation of threats and perceived "crises" around the globe (with corresponding increases in operational tempo [OPTEMPO] and personnel tempo), the current and future Air Force will be required to fulfill more missions in more diverse scenarios ranging from major theater war (MTW) to military operations other than war. Thus, the Air Force must develop and field a robust and integrated force management capability that enables deployed and home-based AEFs to accomplish *all* assigned missions—ranging from traditional warfighting to peacekeeping and humanitarian assistance—regardless of forward operating conditions.

The AEFs are anticipated to operate in a split-base manner with combat power forward and reachback for support. This puts increased demands on communications, information displays, and shared databases. The C^2 system for the AEFs is evolving through spiral development and the Joint Expeditionary Force Experiments (JEFXs). This process spurs innovation but imposes additional constraints on the systems engineering disciplines.

The integrated C^2 system is a management approach to tuning the C^2 system as a weapon. The Integrated C^2 System (IC^2S) task force concept of operations (CONOPS) outlines how the systems will work together. To implement the IC^2S, a Systems Program Office has been established at the Electronic Systems Center (ESC) with responsibility for the overall acquisition management of the systems within IC^2S, such as Theater Battle Management Core Systems (TBMCS). The architectural direction (the integration of operational, systems, and technical architecture) for the IC^2S is being defined at this time.

The environment for communications in general is changing rapidly. Areas of the world without commercial broadband connectivity are being reached through the global fiber network and satellite networks. The use of these resources for OOTCW is inevitable because of the additional capabilities these resources provide and the fact that many participants do not have access to military networks. This implies that the military also needs access to those communications networks.

The use of commercial networks implies potential vulnerabilities that must be addressed. In some cases the adversary may be using the same network, which presents interesting considerations in forms of

[1] MSgt Jim Katzaman, "Air Force Launches Into Expeditionary Mission," Air Force News Service, 3 August 1998.

offensive and defensive information warfare. The physical vulnerabilities of the commercial networks will probably decrease over time as the networks proliferate, but network assurance and control may become more difficult.

8.0.2 The Force Management Process

The concept of force management,[2] as used in this study, is broader than C^4ISR. *Force management* is defined as *the process of developing, executing, and assessing the application of aerospace power to meet mission requirements*. Consequently, it includes the strategy-to-task analysis of the mission, the development and evaluation of alternative courses of action (COAs), and the selection of a particular COA that drives the planning and execution cycle. However, the nature of OOTCW is such that emphasis needs to be placed on the early and timely assessment of the effects of the operation so that changes in the selection of the COA can be made.

Force management in OOTCW requires a rapid response to multiple, simultaneous missions in unforeseen situations where multiple coalition partners, nongovernmental organizations (NGOs), and agencies conduct actions under strong political oversight.

Additionally, the Air Force offers a wide range of effects-based alternatives. Effects-based planning involves selecting alternatives through a process of determining desired effects, selecting a COA, and assessing the resulting effects. Specific elements of effects-based planning as it relates to applying aerospace power include

- Determining *what* effects best achieve desired goals and policy end states
- Linking and integrating effects into a theater-wide scheme of maneuver
- Directing maneuver through dynamic, real-time, predictive C^2
- Precision attack of mobile and fixed targets
- Precision assessment—supporting force, mission, and engagement control

The rapidly changing commercial telecommunications and computer industries have given rise to a potential opportunity and have posed a significant challenge to force management systems. The opportunity afforded force management systems is characterized by the ability to leverage the extensive infrastructure of commercial systems, including the large research investment of the industry. Challenges resulting from the use of commercial technology include (1) acquisition reform[3] required to implement a successful program, (2) offsetting the technology "leveling" of products available to anyone, and (3) long-term support and "tech refresh" strategies required to keep systems capable and affordable.

The environment of reduced force structure and fewer forward locations impacts the systems that support force management. With fewer forces being forward based, the forces garrisoned within the United States must rotate into theaters of operations in AEFs. The force management system must deploy with the forces and not rely on having a strong infrastructure in place. Austere operating bases will be the norm. Thus, a *lightweight, easily configurable, scalable, and adaptive system* is required. The system will have to interface and communicate with allies, other government services and agencies, and nongovernmental agencies. Furthermore, the force management system must respond globally and across the spectrum of conflict.

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2 The 1999 Joint Warfighting Science and Technology Plan references the Advanced Battlespace Information System (ABIS) Study that first used the concept of Integrated Force Management. Per the ABIS Study, commanders need information superiority to shape and control conflicts, and Integrated Force Management represents "the capabilities needed to achieve dynamic synchronization of missions and resources from components and multi-national forces located anywhere."

3 See also the SAB 1999 Commercial Off-the-Shelf (COTS) study.

The threats facing the force management system will include IW, asymmetric warfare, the proliferation of weapons of mass destruction, and the revolution in military affairs. Air Force capabilities enabling force management include speed, range, flexibility, survivability, precision, and theater-wide perspective.

Fielding a force management capability to support AEFs will *not* require a significant shift in the Air Force mission, vision, or goals. However, force management of AEFs in OOTCW scenarios will require a significant expansion of the existing scope of Air Force C^2 doctrine given the increasing number of uncertainties associated with OOTCW missions. As concepts and doctrine for the EAF deployments and OOTCW missions continue to evolve, appropriate operational, systems, and technical architectures must be developed in order to ensure that AEFs are equipped to accomplish their missions. Likewise, technological innovations must be developed, tailored, and fielded to support the personnel using the communications systems to dynamically plan, execute, and assess OOTCW missions.

8.0.3 Communications

Since global communications have become a reality, the importance and impact of communications have grown, and military operations have not been immune. During Desert Storm, the primary American advantage was in information technology—an advantage that will need continued attention if it is to be maintained. The evolution to the EAF concept represents attention to this and other concerns.

The EAF concept was used as the context for the Force Management Panel's evaluation of communication needs and technology solutions. Additionally, increased demand for communication needs for OOTCW were considered to be more demanding but required the same basic capability as MTW. OOTCW were considered to be more stressing in five areas:

1. Communication to support AEF units must be rapidly configurable and deployable to uncertain locations anywhere on earth. This creates demands on methods of supplying power and connecting forward communications back to the continental United States and sharing information.
2. Bandwidth and user interface at deployed locations need to be equivalent to the home station environment so that AEF units "fight the way they train." Sharing critical information in real time across the spectrum of users from the National Command Authority to the shooter places demands on bandwidth. Additionally, the presentation of information across the spectrum of users needs to consider the human-system interface (HSI). Information support to shooters requires increased visibility of the appropriate data to prevent fratricide and collateral damage. The appropriate data needed by the shooters include situational assessment, target description, rules of engagement (ROE), and combat identification and geolocation.
3. OOTCW require full connectivity and interoperability with joint, combined, and civil authorities in the area of responsibility and allied nodes. OOTCW place greater emphasis on coalition forces and coordination with NGOs.
4. Capability needs more flexible pull to get the right information in a usable form to the right place at the right time without regard to barriers of human language, computer protocols, formats, or intelligence discipline. The potential for technology to overcome barriers of interoperability has not matched needs. This is most apparent in current operations with the lack of multilevel security (MLS), configurable networks. These networks need to be virtual so that validated users can access information from remote locations.
5. Military communications will depend on commercial systems. Currently, the U.S. military relies on commercial satellites for approximately 95 percent of its communications.[4] One example is the

[4] David S. Alberts and Daniel S. Papp, *The Information Age: An Anthology on Its Impacts and Consequences*, Washington, DC: National Defense University, 1997, p. 524.

Predator unmanned aerial vehicle (UAV) used for surveillance.[5] Another is the growing importance of morale calls, including voice calls, video teleconferencing, and e-mail. The advantage of commercial communications is that they provide redundancy to military systems and decrease the demand for military systems. The primary disadvantage of commercial systems is that links are set up by commercial vendors and may not be responsive enough to military needs.

8.1 Operational Challenges

The application of aerospace power across the spectrum of conflict and to OOTCW in particular represents specific challenges to force management and to communications. The challenges are developed in the following paragraphs.

8.1.1 The Force Management Process

The EAF mission supporting the joint vision for Global Engagement requires the Air Force leadership to be prepared to respond to a broad spectrum of contingencies, ranging from MTW to small, short-term, localized conflicts. Operational requirements associated with OOTCW tend to be unique, dynamic, and highly situation-specific, often *imposing novel and largely unpredictable demands on Air Force resources*. Successful execution of OOTCW will require that the Air Force C^2 architecture, doctrine, processes, and systems effectively adapt to these operational demands. Some of the implications for Air Force force management are discussed in the following paragraphs.

Flexibility

The multiplicity of potential adversaries and threat scenarios makes it virtually impossible to anticipate with any degree of accuracy the nature, timing, or dimensions of future conflicts. Effective response will require unprecedented levels of flexibility on the part of the command authority in pursuit of mission goals. An agile force management structure will need to rapidly assemble, deploy, and support a tailored force with the right mix of operational capabilities to achieve the intended outcome. The C^4ISR elements of the force must also be scalable to the need, maintaining a minimum forward footprint. The inherently complex interactions of military, economic, social, and political factors will demand a high degree of responsiveness to changing demands as events unfold.

Information Demands

The complex and dynamic nature of OOTCW places unique demands on Air Force information resources. The development and maintenance of a Common Operating Picture (COP) will require a high degree of integration of C^4 and ISR assets, supported by real-time information collection, processing, dissemination, and feedback mechanisms. In this information-intensive environment, the capability to disrupt and/or exploit an adversary's information systems while protecting friendly information assets will be of paramount importance.

Concurrent Operations

Recent events suggest that the Air Force will continue to be required to support multiple, concurrent operations that may involve remote and widely separated geographic locations with varying infrastructure. This will necessitate effective prioritization and continual reassessment of resource allocation. Overlapping commitments will also create surges in OPTEMPO, with important implications for training, readiness, morale, and personnel retention.

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[5] Maj Schafer, USAF, "UAV Challenges in Bosnia," briefing, Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center, Langley Air Force Base (AFB), 1 March 1999.

Joint, Combined and Civil Operations

Response to future contingencies will undoubtedly involve joint and/or combined operations with shared C^2 authority. The ability to collaborate and interoperate with other services, government agencies, coalition partners, and NGOs while maintaining effective operational security is an essential requirement for force management in OOTCW.

8.1.2 A Description of the Force Management Process

The process diagram in Figure 8-1 identifies four principal functions of force management and four feedback mechanisms that enable these functions to be accomplished. This model provides a framework for discussion of the specific operational challenges associated with force management in OOTCW. This conceptualization of force management expands the conventional C^2 process to include not only the traditional Battle Damage Assessment (BDA) feedback loop referred to here as “action assessment,” but also three other feedback loops.

The “dynamic battle control” loop allows for changes in the plans after the air tasking order (ATO) has been issued, while the longer loop involves assessment of how well the actions being taken are achieving the desired effects or how well the goals are being met. Each one of these loops precipitates different responses. The “dynamic battle control” loop affects the execution of the air tasking process (represented by ATO execution) by doing real- and near–real time retasking of assets. The “action assessment” loop (formerly the BDA loop) affects the development of the next ATO. The “goal/effects assessment” loop leads to the reconsideration of the COA being followed and possibly to the selection of an alternative COA to meet the changing circumstances.

The “dynamic battle control” and “goal/effects assessment” loops are covered by this panel. However, the study does not address the real-time shooter assessment loop, denoted “execution control,” except to recognize that all assessment emanates from common data, much of which has its genesis at the moment of the event. The distinction between execution control and dynamic battle control is that the latter involves the controllers and sometimes the planners.

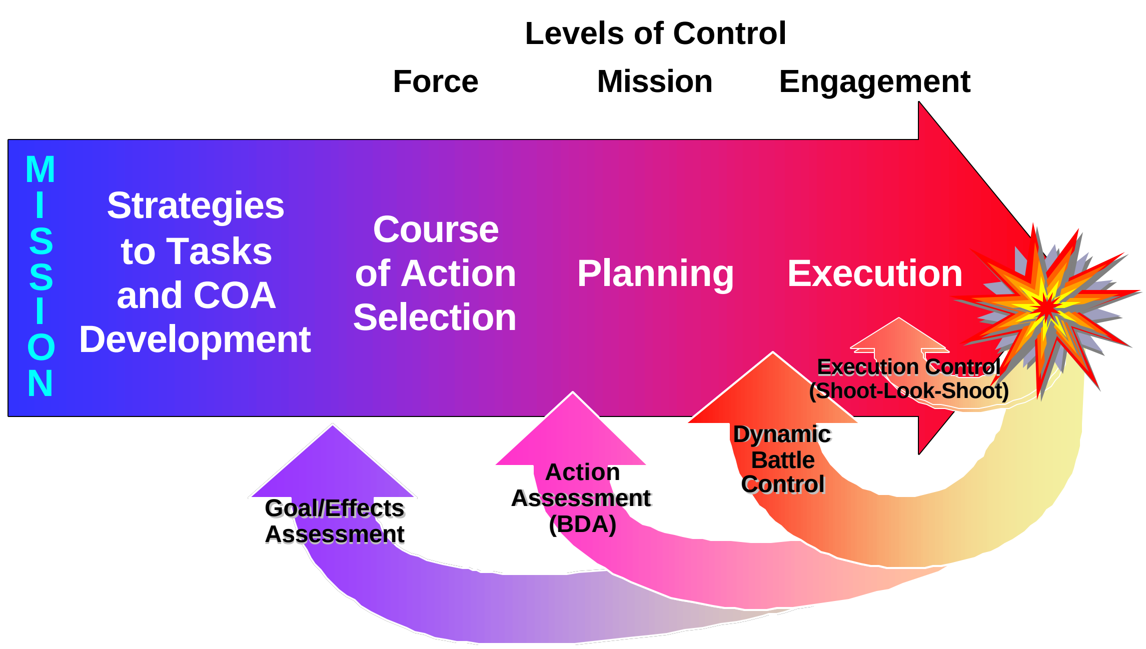

Figure 8-1. *A Notional Representation of Force Management*

Course of Action Development

Alternative COAs are derived from the overall mission objectives through strategy-to-task decomposition. In the context of OOTCW, the overall goal of the political authority may be ill defined (often intentionally) or poorly articulated from a military perspective. The battle planner must interpret these goals and translate them into desired effects on specific targets. The effects may include denying a capability to the enemy, disruption of a capability, or destruction of enemy forces, facilities, combat equipment, or infrastructure. To achieve the desired effects, the planner must consider the full range of options from information operations (including psychological operations [PSYOP]) and other non-lethal means to employment of conventional or precision munitions. Effective COA development requires complete, accurate, and timely intelligence on target status, weapons availability, and the capabilities and limitations of adversary defensive means.

Course of Action Selection

Selection among available options represents a complex and dynamic risk management problem, often involving high levels of uncertainty. The optimum COA can be highly dependent upon the outcome of prior (or concurrent) events, requiring continual feedback (goal assessment) as the engagement progresses and enemy tactics change. Interdependencies among actions (for example, sequential or enabling actions) must also be addressed dynamically so that potential conflicts can be resolved, ensuring that COAs are mutually supportive. Another major challenge in COA selection is to ensure that the combined effects of the selected actions collectively support the higher-level goal and strategy. The complexity and latency of this process may also be influenced profoundly by the need to obtain consensus on individual COAs among allies or coalition partners.

Planning

OOTCW are often initiated in response to unanticipated world events, providing little or no lead time for operational planning. This reality imposes a need to simplify, streamline, and shorten the planning cycle as much as possible and, once started, to maintain a high degree of adaptivity. Logistics planning for deployment and support must be highly responsive to changing demands. A key enabler is timely, accurate, and complete intelligence about the local area of deployment, including the infrastructure, physical environment, political situation, and cultural factors. Rapid and accurate action assessment is also essential to minimize risk to the warfighter and optimize resource utilization. OOTCW require greatly improved capability to perform damage assessment, including the effects of actions employing unconventional means (non-lethal, IW, etc.). Mission planning for OOTCW also requires effective communications and interoperability across joint or combined command structures. The ATO is a key product of the planning process.

Execution

The most fundamental force management challenge for execution of OOTCW is that of establishing and maintaining real-time situation awareness at all levels of command authority from the Joint Force Commander (JFC) to the shooter. The dynamic nature of OOTCW makes it essential that C^4ISR resources have the necessary connectivity, processing capacity, communications bandwidth, and human-system interface to enable “dynamic battle control,” including real-time mission replanning. A substantial technical challenge is the integration of target, threat, and environmental information from multiple off-board sources into the cockpit to support timely tactical decisions by the aircrew. The effective use of assets (UAVs, off-board sensors, etc.) for mitigation of risks to personnel also represents an important operational challenge for force management.

Dynamic Battle Control

Improvements in sensors, collection management, and dissemination of battlespace information make it possible to make timely changes to the ATO before and during execution. This capability, sometimes referred to as replanning, is described more accurately as dynamic battle control. Insertion of new tasks, deletion of tasks that are no longer necessary, redirection of assets, and reallocation of resources in response to changes in the battlespace are all part of dynamic battle control.

Action Assessment

The middle assessment loop is entitled "action assessment (BDA)." It is the feedback and interpretation of the results of execution to the planning function. BDA is the traditional function of assessing whether the effects of the bombs dropped in a small number of daily sorties have accomplished the level of destruction that was specified in the weaponeering of the sorties. As such, it is a signal for the sortie planners to move forward to assigning sorties against the next target rather than restriking a target that may already be demolished. Timely and accurate BDA can multiply the effectiveness of the air campaign by a significant factor, limiting restrikes and making sure that appropriate levels of destruction are achieved. However, lack of sensors, bad weather, and slow processing and communications have often resulted in delayed and partial BDA, which in turn has greatly limited the actual and perceived effectiveness of the air mission.

In the context of OOTCW, BDA must be considered more broadly because the types of actions taken may be far different from the traditional task of "bombs on target." Moreover, there is more difficulty in achieving accurate and timely action assessment, the equivalent of BDA, for the broader missions of OOTCW. OOTCW may be delivery of medicine, patrol of an area, tracking of a specific suspected vehicle, or measuring something as difficult as level of intimidation or suppression. If information operations are conducted, the mission may be delivery of leaflets, jamming or pressure on an enemy population, or corruption of a database. Clearly, measuring the results of these missions requires a broad range of sensors, processing, and analysis to establish whether it is time to move to another target.

Traditional action assessment has sometimes simply relied upon self-reporting. That is, if 10 sorties were scheduled, it is reported that 9 took off, 8 reached the target area, 7 were able to see the target, 6 executed delivery, 5 reported explosions, and 4 saw that damage occurred. For some OOTCW missions, the analogous report of a sortie flown and tons delivered is adequate. For other missions, both BDA and its analogy for OOTCW are considerably more complex.

With regard to BDA, the Gulf War saw considerable controversy over whether the air mission against ground targets had been fully executed so that the ground war could begin. This was partly due to poor weather, slow communications, and the lack of appropriate sensors. As a result, many restrikes were flown that may have been unnecessary. Since every sortie has risks, this means that a substantial unnecessary risk resulted. An additional problem, however, was the definition of the level of destruction required. The JFC wanted reduction of the ground forces' capability by 50 percent. This came to be defined in terms of attacks against artillery and armor formations. The photo interpreters believed this required photographic evidence that half of the artillery pieces and half of the tanks had been destroyed across the formations in the defensive lines. The JFC was finally convinced that the effectiveness of those units had been reduced by 50 percent, even though the stricter definition had not been reached. After the war, examination of tanks on the ground indicated that fewer than 10 percent had been destroyed from the air.

The action assessment process for some OOTCW missions is immature and considerably more difficult than traditional BDA. Often the final arbiter of success is higher civilian authority or even the media. The definition has to be more than missions flown, but the connection to mission accomplishment cannot be done by photo interpretation alone. Sometimes the addition of information from other intelligences

solves the problem. If electronic intelligence indicates that the warning radar shut down, then suppression at least occurred. Measures and signals intelligence (MASINT) may indicate that the desired effect occurred. Communications intelligence may reveal the thoughts of leaders. Unfortunately, the fusion of the intelligences takes time and often is uncertain. For objectives including the hearts and minds of populations, there is no Joint Munitions Effectiveness Manual or technical intelligence available … human intelligence may be of considerable value but is slower and more uncertain.

No easy solution is available across OOTCW, but it is important to regularly assess the detectable results against the objectives of the mission. Usually a goal of completed missions can be identified for a time period. It is important to define the levels of partial completion and to make an unbiased count of the completion level and the characteristics of the "targets" flown against. Analysis can then make sure that the distribution of completed sorties is maintained across the targets. Similarly, the sorties must be maintained against the harder targets as well as the easy ones. This is the first level of action assessment: Did we thoroughly do what we had planned at the intensity rate planned?

The second level of action assessment is the correlation against intermediate effects. Since the ultimate objective of the OOTCW mission may be difficult to quantify or its accomplishment may become apparent over a long period, some intermediate measures of effectiveness (MOE) are defined that can be tracked daily or weekly. These must be related to the sorties flown or the equivalent actions. For example, intimidation might have a MOE of thousands of personnel exposed to visual or sonic effect. With such measures, the progress of the campaign can be tracked in surrogates or proxies. Trends and anomalies can then be seen and reasons for changes can be sought through analysis and diagnosis.

The top level of action assessment in OOTCW is the analogy of the fusion of intelligences for quick assessment in BDA. In operations such as anti-drug, anti-terrorism, or no-fly-zone patrol, the fusion is very similar to that for BDA. However, for less warlike missions the correct set of sources and correlation processes is difficult to identify and even harder to put in place for daily or even weekly evaluation. Sources typically include the media (adversary, domestic and international), the diplomatic and humanitarian communities, open-source statistics, and traditional area expertise in academia, government agencies, etc.

These three approaches to action assessment of OOTCW should be adequate to perform action assessment for most OOTCW and to allow more rapid completion of the mission.

Goal and Effect Assessment

The process for development and selection of COAs, as now implemented, is essentially a one-way, hierarchical decomposition of strategy to tasks. It does not yet incorporate a formal, dynamic feedback mechanism to assess and exploit information about the results of prior actions in the selection of subsequent COAs. The complex and unpredictable nature of OOTCW requires a more effective means of closing this loop to ensure that the intended relationship between COAs and overall mission goals is preserved as the engagement progresses. To fully realize this capability, the process for COA development and selection and the supporting feedback mechanism must address the following needs:

- An effects-based convention for terminology used by analysts in performing the strategy-to-tasks decomposition
- A disciplined, structured procedure for identifying and evaluating alternative COAs, supported by effective training in techniques for building and maintaining consensus
- Tools and methodology to correlate probable COA effects with objective constraints (for example, stay-out areas)
- Explicit and quantifiable criteria for evaluating the extent to which a desired effect has been achieved

- Tools to support the identification and tracking of interrelationships among COAs (sequential dependencies, enabling tasks, etc.)
- Means for obtaining and using timely feedback on the outcome of actions involving unconventional means (offensive IW, PSYOP, non-lethal weapons)
- Methodology for rolling up the collective effects of multiple COAs to assess their combined effects relative to the overall mission goal

One of the observations about effects-based assessment is that it requires the integration of the intelligence and planning functions. Fortunately, technologies are emerging to support this integration. For example, influence net modeling, when coupled with executable models of operations, provides a common environment for relating events to effects so that COAs can be developed, analyzed, and compared. The same tools can be used to assess the evolution of the engagement and trigger the consideration of changes in the COA.

8.1.3 Communications

Communication, in its purest form, is the process of transmitting and receiving data and information. In its simplest form, communication is accomplished within a closed loop of cognition, transmission, and reception. Communication systems provide the ways and means to transmit and receive data and information between intended participants. Information architectures provide, in turn, the end-to-end capability to transmit and receive data and information among intended participants. Outside this closed loop are the sender's intent and the recipient's perception of the desired intent of the data and information. Thus, the focus of communication is data and information.

To meet data and information requirements for future military operations ranging from MTW to OOTCW, technology innovations are required to provide communications that balance timeliness, accuracy, flexibility, and security. For the purpose of this discussion, working definitions of these fundamental and enduring characteristics are provided as follows:

- *Timely*: Data and information move as fast as necessary to arrive within a prescribed time window
- *Accurate*: Data and information content is not changed within the architecture
- *Flexible*: "Plug and fight" capability exists with other systems and architectures
- *Secure*: Data and information are not accessible by unauthorized users

Several technology innovations are needed to meet current and projected military communications requirements for OOTCW: wireless, multilevel secure communications; a high-capacity, deployable telecommunications port; a fully integrated "kill chain" of information sources; automated network management tools; and remotely reprogrammable hardware and software.

In addition to the technological innovations needed to enable communications for EAF missions in OOTCW scenarios (for example, hardware end-items), many nontechnological innovations must be developed in parallel that support the technology. For example, personnel who will eventually operate the new and improved communications equipment must be adequately educated and trained to meet their mission requirements. Likewise, personnel who are developing and integrating the technologies must have adequate tools to support their R&D efforts and to estimate the military worth or operational utility of a given technology innovation. These tools include computer-based modeling and simulation programs that can be used to support study, analysis, assessment, and visualization. Finally, the synergistic benefits of influencing and leveraging commercial practices and products to meet EAF mission requirements need to be realized. For example, database standardization initiatives not only

improve mission effectiveness by allowing interoperability between and among systems, database standardization will also benefit *intra*operability within systems and should improve the utility of computing innovations such as field-programmable gate arrays (FPGAs) and intelligent agents.

Wireless, Multilevel Secure Communications

Wireless, multilevel secure communications will enable military forces to operate in a full spectrum of operational conditions ranging from remote, bare-base locations to bases with relatively mature communications infrastructure (for example, regularly scheduled AEF deployment locations). Wireless communications are necessary to support datalinks, local area networks (LANs), and personal communication systems (for example, digital cellular phones and pagers). Wireless LANs will also

- Provide the flexibility to adapt to prevailing operating environments
- Reduce the logistics footprint for deployed communications systems
- Decrease setup time

MLS will enable U.S. forces to operate with allied, coalition, and civil partners (such as the International Red Cross or Red Crescent). Likewise, MLS will facilitate the dissemination of data and information between systems and architectures that process classified data and information (such as "sanitized" data from National Technical Means).

A High-Capacity, Deployable Telecommunications Port

A high-capacity, deployable telecommunications port will enable the movement of increasing amounts of data and information to an increasing number of end-users operating in an increasing number of geographically separated locations. To increase communication bandwidths, the military should leverage commercial investments in data-compression algorithms, router and switching technologies, and fiber optics that will likely provide the greatest bandwidth capability in the near term (that is, within 5 years). Beyond 5 years the military should stay abreast of the commercial state of the practice as it evolves.

A Fully Integrated "Kill Chain" of Information Sources

The focus of most military communications systems has been the movement of data and information to an end user (for example, downlinking imagery data from airborne reconnaissance platforms to a ground station, sending the ATO to a deployed Wing Operations Center, or passing target or threat coordinates to an ingressing aircrew). In most of these system examples, the flow of data and information is essentially one-way and point-to-point. Recent advances in communications technology fielded on ISR, C^2, and shooter platforms should enable full-duplex, broadcast communications of available information. For example, the mission assessment process for air-to-air and air-to-ground missions would be improved if the future weapons were equipped to simultaneously backlink available Global Positioning System and electro-optical/infrared (IR) data to the shooter and battle manager. For deep interdiction scenarios, the data could be recorded onboard the shooter and used for post-mission analysis and BDA. An extension of this concept includes using satellite platforms to uplink and downlink data to platforms beyond the line of sight for real-time and non–real time mission assessment. The intent of integrating the kill chain in this manner is to improve the feedback and mission assessment process for all OOTCW missions—at the engagement, mission, and campaign levels.

Automated Network Management Tools

Decision makers and information managers at all levels readily admit that they are usually data rich and information poor. To help alleviate this existing problem, which is compounded by decreasing numbers of military personnel and increasing OPTEMPO, tools such as intelligent agents have been developed that reduce the workload for tasks that are relatively menial as well as tasks that can be very complex. In the

simple case, intelligent agents can be used to monitor computer server disk space capacity and communications networks (for example, message buffers and message traffic monitoring). More advanced applications should be developed to enable “smart” queries and management of existing data sources using adaptive learning techniques. For example, an agent could be programmed for a given interdiction sortie (and per the scenario-specific ROE) to automatically nominate targets to ISR collection managers, provide current threat electronic order of battle information along the pre-planned ingress route, provide updated information during the mission, and provide dynamic updates in the event the mission is diverted.

Remotely Reprogrammable Hardware and Software

Given the uncertainties associated with current and future OOTCW missions, hardware, software, and algorithms will need to be increasingly flexible and robust in order to adapt to prevailing conditions and operating environments regardless of deployment, location, duration, intensity, or force composition (for example, joint or combined forces). FPGAs, for example, allow computer chips to be dynamically reprogrammed and tailored for specific applications and scenarios. Likewise, similar technology should be fielded to reconfigure communications antennas via changes to existing software and algorithms. For software and algorithm changes, the goal will be to field a capability whereby changes can be initiated and verified remotely (for example, reprogramming network protocols on airborne or satellite surveillance platforms). The design of communications hardware will continue to evolve and be robust with respect to accommodating new software and algorithms and to functioning in diverse operating environments (for example, modular designs).

8.2 Force Management Findings

There are two primary considerations in addressing force management issues. First, the EAF concept poses new challenges in C^2, communications, information management, and force protection. Second, the diversity of missions included in OOTCW requires a total systems approach to the design of a C^4ISR system. When these two considerations are taken together, they point to the need for *developing capability well beyond that required for conventional MTW*. Specific findings are discussed in the following paragraphs.

8.2.1 The Operational Concept for EAF

With the rapid changes in the past several years, the Air Force has not yet had an opportunity to develop and articulate an operational concept for the EAF in conducting OOTCW. The Global Engagement Operations (GEO) construct is a major step in the right direction, but the Shape and Reshape stages need to be developed further to cover OOTCW elements and functions.

8.2.2 The Operational Architecture for EAF

The JEFXs with the underlying spiral development process are an excellent way of evolving operational concepts and systems. They generate and test ideas and concepts, and they put new components and systems in the hands of the operators to try them. However, for the results of the JEFXs to be truly useful in the long term, they need to be framed within an evolving operational architecture and the corresponding systems architecture. The spiral development process is not a substitute for systems engineering, but is one part of the systems engineering process.

This is an environment in which operational concepts are evolving and technology is changing, offering new opportunities. At the same time, the variety of missions that the EAF is expected to do is expanding. An operational architecture for C^4ISR is an essential tool to ensure that user requirements will be met and that interoperability will be achieved.

8.2.3 The Shift to OOTCW

The current systems and the systems to be deployed in the near future were conceived and designed to support conventional MTW. They will not adequately support either the force management needs of the EAF or the application of appropriate aerospace power to OOTCW. Specifically, systems, doctrine, and tactics, techniques, and procedures (TTP) for information support of an AEF in OOTCW are not yet sufficiently mature to support rapid response to nontraditional missions in unanticipated locations and environments.

8.2.4 The Force Management Core System

A consequence of the previous three findings is that the TBMCS version 1.0x will not adequately support either the EAF force management needs or the application of aerospace power to OOTCW. The reasons are easily understood. TBMCS was designed to address deficiencies observed in Desert Storm; its design precedes the evolution of the concept of an EAF and the realities of OOTCW with their many operational constraints. Furthermore, OOTCW, more often than not, require the careful integration of information operations with non-lethal and lethal weapons application. Also, OOTCW will be joint and will probably include allies, coalition nations, and NGOs. This finding reflects on the suitability of TBMCS version 1 and is independent of the implementation effort currently in progress.

8.2.5 The Human-System Interface

A related finding is that inadequate attention has been focused on the HSI of the TBMCS version 1 implementation, making the use of the system cumbersome and especially inhibiting training. The lack of elementary features such as hourglass icons or sliders showing that the system is working on the user's request in the TBMCS version seen at the C^2 Training and Innovation Group causes frustration and leads to human responses that result in deterioration of system performance. The lack of a consistent user interface across software modules limits efficiency in the cross-training of operators in the use of multiple tools. Similarly, realization of the COP requires substantial attention on cognitive and human-system interface issues.

8.2.6 Science and Technology Support of OOTCW

Past science and technology investments are producing tools and techniques for improved force management. However, the absence of an operational architecture for an AEF conducting a full spectrum of operations (both conventional and OOTCW) inhibits the early transitioning of these technologies to the operators. New concepts in COA development and selection, in effects-based targeting and assessment, and in dynamic replanning and dynamic battle control could provide needed capability to the Air Force. The panel envisions a close collaboration between the Air Force Research Laboratory, Information Directorate and the Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center (AC2ISRC) and between the Center and ESC, as shown in Figure 8-2, to bring these technologies to the warfighter.

Figure 8-2. *Interrelationships Among AFRL, AC2ISRC, and ESC*

Specifically, traditional C^2 and ISR need to be perceived as elements in the same closed C^2 loop: collection management, processing, exploitation, and dissemination need to be integrated with planning and execution. Furthermore, the blurring of the distinctions between sensors, reconnaissance systems, targeting, attack, and assessment systems as data collectors requires developin g a comprehensive C^4ISR architecture.

8.3 Force Management General Recommendations

A multistage process is recommended for addressing the key findings—namely, the implementation of a force management capability for the EAF and for OOTCW. Recommendations are shown in italics.

8.3.1 Force Management Strategic Concepts Group

There is need to direct an existing group of O-5 or O-6 officers drawn from the major commands, or to constitute one, to articulate a clear operational concept for the EAF and for the application of aerospace power to the full spectrum of OOTCW. The operational concept should be in sufficient detail to be usable for the generation of the operational architecture. A more general recommendation is for the Air Force to empower such a group annually to formulate a series of operational concepts for future force management and use the results as inputs to the requirements process and to the conduct of JEFXs.

Empower a group at the O-5 or O-6 level (possibly an existing one), chaired by a general officer, with the charge to develop an operational concept for the EAF in conducting the full spectrum of operations (OOTCW and MTW). It could also expand the GEO to include key components of OOTCW in the Shape and Reshape stages.

8.3.2 Develop the Operational Architecture

The operational architecture is a means of formally expressing how operators envision the EAF conducting OOTCW and conventional MTW. The focus of the operational architecture should be the complete force management process, as shown in Figure 8-1, and include the integration of ISR with C^2. The operational architecture is to be driven by the operational concepts developed by the strategic studies group and is to be used to define the operational requirements. This is an iterative and ongoing process.

Develop an operational architecture based on the operational concept developed by the strategic studies group and coordinate this development with ESC.

8.3.3 Develop a Systems Architecture

Develop a systems architecture that implements the operational architecture (taking into consideration legacy systems and their interfaces) and that enables the integration of combat intelligence, planning, execution, and multilevel assessment. The associated technical architecture must also be defined.

In collaboration with AC2ISRC, develop the systems and technical architectures that correspond to the operational one developed by AC2ISRC.

8.3.4 Assign a Chief Architect

The operational, systems, and technical architecture views of C^4ISR require different expertise for their development. It is critical, however, that all three be developed in a highly coordinated manner under the direction of a single architect with overall responsibility. Therefore, there is clear need for the Air Force to assign a single authority, a Chief Architect, with responsibility to coordinate the development of the operational, systems, and technical architectures and to assure that the resulting C^4ISR architecture is maintained and revised, and adherence to it enforced. This C^4ISR architecture should be used as a

guideline for selecting concepts and systems to test in the JEFXs and evolve the architecture to include the findings from the JEFXs.

Identify a Chief Architect for the Air Force with responsibility for coordinating architecture development, maintenance, revision, and enforcement with early focus on force management and air mobility for the EAF in OOTCW.

8.3.5 Expedite the EAF Force Management Core System

The objective of this recommendation is to provide the Air Force with a flexible, scalable, and reconfigurable capability for force management that can meet the needs of the full spectrum of operations. Current systems and procedures appear to focus mainly on MTW and on the application of lethal weapons to physical targets. OOTCW appear to be increasing in frequency and cover a wide spectrum of situations. A *scalable* force management capability that can interoperate with the other Services and with allies, coalition partners, and civilian and nongovernmental organizations, is a must. Furthermore, it should focus on effects-based targeting and on the ability to generate and assess a wide variety of COAs that include both lethal and non-lethal weapons as well as information operations. Such a capability should stress the three feedback loops shown in Figure 8-1. The complex political objectives and changing operational constraints in the conduct of OOTCW necessitate the inclusion of both dynamic battle control and effects/goal assessment.

Therefore, the Air Force will be well served in the future if it expedites the development of an EAF force management system designed on the basis of the C^4ISR architecture (operational, systems, and technical) (TBMCS version II).

Initiate an accelerated program, based on the operational, systems, and technical C^4ISR architecture views, for the design and implementation of a force management system (TBMCS II).

8.3.6 Selectively Deploy TBMCS

Based on the accumulated evidence, the panel believes that the TBMCS version 1.0x will not meet the Air Force needs for the EAF in OOTCW now or in the future. Several specific recommendations address readily observable deficiencies and, if implemented, will make the system operate better in the short term. However, its long-term prospects, based on the underlying architecture, are very problematic and bring into question of whether the Air Force should invest in its further development beyond the currently scheduled releases (1.x). The Air Force should deploy TBMCS 1.0x to those elements of the force for which TBMCS will provide capability they currently lack, provided that some fixes in the software are made, especially those that will increase ease of training and use. But the panel believes that the Air Force will be better served by redirecting its funds to the development of the TBMCS II with an accelerated schedule following the stages described in these recommendations.

Deploy selectively TBMCS version 1.0x in the near term and undertake needed software fixes, but do not invest in developing new capabilities for it.

8.4 Force Management Specific Recommendations

Specific recommendations including suggested action relating to the force management process are detailed in the following paragraphs.

8.4.1 Recognition of All Three Force Management Feedback Loops

To institutionalize the three assessment feedback loops within the force management process, the Air Force must incorporate them into doctrine and TTPs. While it appears that the Air Force intellectually

recognizes and agrees that the three feedback loops (or the elements contained within the loops) are essential, it is not clear that these key parts of the process and the mechanisms by which they are accomplished have been internalized or reflected in the requirements process. The Air Force should determine how the feedback will occur and should develop an application and tools to turn the feedback data into information and knowledge.

Recognize in doctrine and TTP that all three feedback loops in the force management process are essential and develop tools and techniques to use them.

8.4.2 Integrating Experiment Technologies

AC2ISRC and ESC should ensure that there is a detailed transition plan for JEFX technologies that enables the Air Force to take timely, full advantage of results. The transition plan should identify resources, particularly staff and funding, to implement and integrate the change into the IC^2S. In addition, the plan should ensure that the change eventually takes hold throughout the Air Force, and that *sufficient training resources* are identified for every implementation phase.

Prepare a transition plan and staff for implementing JEFX results.

8.4.3 Experimentation Follow-Up

The success of applying the force management process relies heavily on communication technology and on automation. Future success will depend upon constant, rapid insertion of the latest enabling technologies. Air Force experimentation is the venue for these technologies to be directly applied to force management CONOPS advances and inserted into the operational Air Force. To realize this timely technology insertion, the Air Force must put into place and strictly adhere to a process identifying

- How the lessons learned affect the requirements and acquisition process
- How appropriate Air Force entities approve the recommendations
- How the program changes or requirements actions are to be executed

Examine the process for follow-up of initiatives after experimentation.

8.4.4 The TBMCS Operator Interface

The current implementation of the TBMCS 1.0x human-system interface should be reviewed for compliance with applicable principles, standards, and design criteria for human factors engineering. The practical utility of the battle management system can be fully realized only if the user interface design permits efficient training and error-free (or error-tolerant) performance on the part of the users. In the context of OOTCW, it is particularly critical that a consistent user interface standard be applied across software modules to avoid negative transfer of training. The scalability of TBMCS to support a range of contingencies will be enhanced to the extent that operators can be cross-trained to a level of proficiency in multiple tools and applications. The AFRL Human Effectiveness Directorate can provide substantial capability in support of this design review.

Review the TBMCS operator interface for consistency with human factors principles, standards, and design criteria. Modify the HSI design as necessary to minimize the potential for human error and negative transfer of training across software modules.

8.4.5 The Human-System Interface—a Process for Acquisition of C^4ISR Systems

The acquisition of future Air Force C^4ISR systems must place substantially greater emphasis on design and testing of the HSI. This can be accomplished efficiently, with minimal impact on cost and schedule,

if and *only if* it is addressed systematically from the earliest stages of the acquisition process. An essential element of the human engineering effort is the active involvement of representative user personnel continuously from initial development of the operational concept through system requirements and performance criteria to testing and evaluation of the end product. A common user interface design philosophy and implementation standards should be adopted and applied systematically throughout the development cycle. These conventions should address utilization of display and control media, display symbology, information coding, and operating logic. Rapid prototyping techniques, using commercially available development tools, should be employed in an iterative fashion during spiral development to surface and resolve user interface problems cost-effectively.

Develop and systematically apply common user interface standards and objective human performance criteria as an integral part of the acquisition process for future Air Force C^4ISR systems.

8.4.6 Real-Time Information in the Cockpit

Realization of the dynamic battle control feedback loop of the force management process requires a highly effective crew-system interface for tactical C^2, including real-time information in the cockpit (RTIC). To take full operational advantage of real-time information from off-board sources (target or threat intelligence, weather, etc.), these data must be fully integrated with on-board resources (sensors, stored terrain data, mission plan) and displayed to the crew on demand in a form that can be readily interpreted. It is essential that the crew workload be maintained within acceptable limits to avoid the necessity of adding crew positions. Some key enabling technologies include

- Flight-qualified, large-aspect, high-resolution, color, flat panel displays
- Seamless tiling for composite, high-resolution, wide-field-of-view imaging
- Cursor control devices (track pad, hands on throttle and stick) optimized for the motion and vibration environment
- Touch-sensitive overlays (capacitance, acoustic, IR) as an alternative to bezel keys
- Voice recognition for display configuration, mode switching, menu selection, and cueing
- Mission-adaptive automation (for example, pilot intent inference algorithms)
- A helmet-mounted display, coupled with an externally mounted IR sensor via head-tracker (as an alternative to night vision goggles)

These technologies should be thoroughly evaluated for potential near-term applications to planned avionics upgrade programs including the C-130, C-141, C-5, and B-1B. The current plans to develop and procure Airborne Broadcast Intelligence as a standalone system should be considered an interim solution until a transition to a fully integrated RTIC capability is achievable. First priority for a fully integrated RTIC system should be assigned to mission platforms that operate in a high-threat environment—Combat Talon, Special Operations Low-Level II, gunships, etc. Figure 8-3 shows an RTIC concept that might be employed in an Air Force Special Operations Command tactical airlift application.

Expedite implementation of fully integrated RTIC capability onboard mission platforms that function in a high-threat environment. This should be accomplished as part of planned avionics modernization programs.

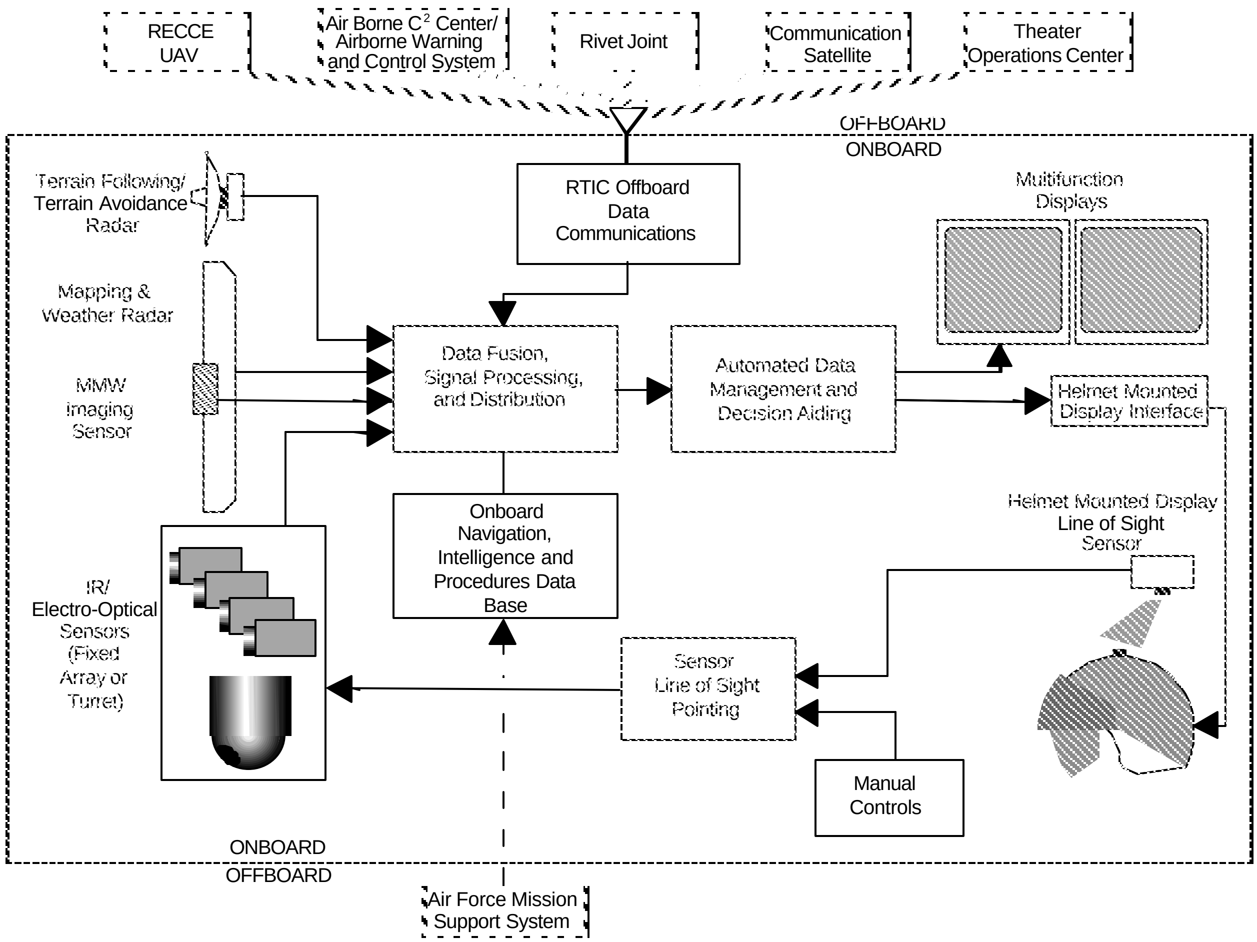

Figure 8-3. *RTIC Concept for Tactical Airlift Special Operations Forces Application*

8.4.7 Scalability of the Current TBMCS (or of the Proposed TBMCS II) Architecture Against the EAF and OOTCW Requirements

OOTCW require an architecture that is comprehensive enough to accommodate a wide range of missions, environmental conditions, allied or coalition command structures, and political constraints. Furthermore, a control system requirement must also scale rapidly as the situation changes and phases are executed. As a means of testing the architecture, numerous cases—scenarios as well as real-world missions and taskings—should be played against the constructs of the architecture, and appropriate metrics gathered. In turn, the metrics could be used to adjust and extend the architectural elements. The architectures should comply with the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence C^4ISR Architecture Framework.

The architecture, as represented statically through the three views, can be expressed as an executable model that can be used to convey the force management system requirements, define its test plan, and describe its interoperability characteristics. Linking the operational architectural products to the requirements process is an absolute must. Use of the architecture products will enable the Air Force to break out of the time-consuming, sequential (linear) process of requirements definition, just as spiral development has revolutionized acquisition.

The 1996 C^2 Summer Study stated that "The Air Force needs…to create a C^2 Enterprise to institutionalize the changes needed in requirements; planning, programming, budgeting system; technology; acquisition; training; organization; and doctrine." The Air Force has made significant strides to correct the organizational shortfalls. Now it needs to continue the course and adjust the requirement definition and acquisition implementation to reflect EAF.

Test the scalability of the force management system (TBMCS 1.x or the proposed TBMCS II) against the EAF and OOTCW requirements and revise it as appropriate.

8.4.8 An Architecturally Driven Requirements Generation Process

For the EAF to achieve the objectives of *Joint Vision 2010* (*JV2010*), systems development should continue to be accomplished in an iterative fashion through JEFX. This will improve the requirements generation process into a complementary responsive system to support spiral development.

It is recommended that the C^4ISR requirements generation process be incorporated into the JEFX experimentation and the spiral development processes. The Air Force needs to break away from the "deficiencies chasing," mission need statement, Operational Requirements Document, Test and Evaluation Master Plan, Specification Process to one that reflects the visionary needs of *JV2010* and the EAF. This iterative requirements process would incorporate architectural views, and needs would be represented through a series of dynamic executable models (see Figure 8-4).

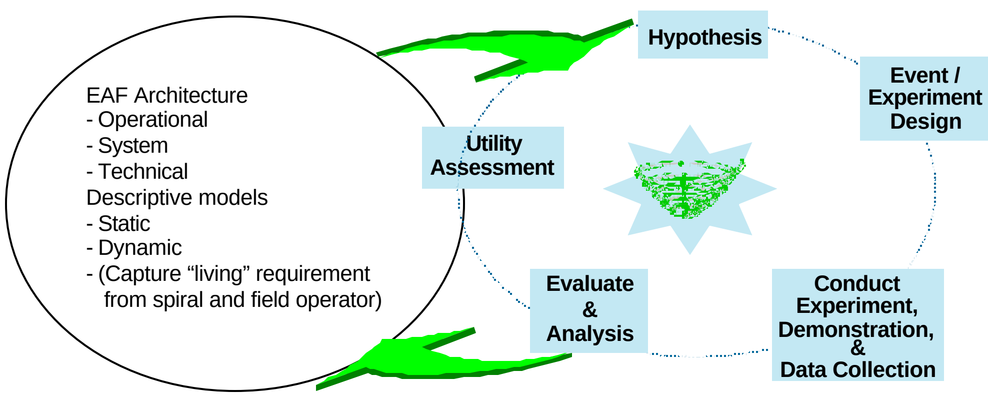

Figure 8-4. *Requirements Process*[6]

The redesigned requirements process, as it relates to force management, must

- Strengthen the funding case (not just preserve what was described as "level of effort" budgeting)
- Set a course for a core C^2 system that defines the future
- Exploit JEFX and spiral development with an architectural requirement based on the EAF
- Integrate commercial technology and manage its incorporation to include ownership cost—design, production, operation, and maintenance
- Seize the moment and recraft TBMCS by initiating the architecture-based TBMCS II (as the Air Force's core C^2 system) and use it to implement a visionary EAF force management capability

[6] See the SAB 1999 Joint Battlespace InfoSphere Summer Study.

Implement a forward-looking and architecturally driven requirements-generation process to match the efficiency of the spiral development process as a prerequisite for TBMCS II. The operational architecture development suggested in this report should be completed by 1 August 2000.

8.4.9 Implications of Force Management

Action needs to be taken to assure that the information systems (including communications systems) are adequate to support all three feedback loops of force management. The three feedback loops addressed by this panel (see Figure 8-1) map to the dynamic decision support needs of commanders operating at the force and mission levels of control in OOTCW. Furthermore, accurate assessment at these levels is strongly dependent on accurate engagement-level information.

A systematic mission capability perspective of the complete assessment process conducted in support of precision attack is required. Accurate information, captured at the "moment of the event" and logically distributed back up the kill chain, can substantially increase effectiveness and reduce cycle times of MTW and OOTCW.

Commercial Technology[7]

Managed and deliberate commercial technology integration policy and acquisition strategy are required for successful integration of modern telecommunications advances. This requires integration of the engineering, manufacturing, and design phase with the production and sustainment phases of acquisition. Acquisition reform will be an important by-product of this restructuring.

Sensor Systems

Research and investment are needed in weapon-borne sensors, weapon-trailing sensors, weapon system systems sensors, and off-board sensors. These must be examined in a functional, mission support, targeting, and assessment-driven process. This process must fulfill the needs of the "shooter" or engagement entities (real-time "shoot-look-shoot"), the dynamic battle control (near–real time asset management), and the action assessment and effects assessment. Two examples are the Naval Air Systems Command's Quick Bolt High-Speed Anti-Radiation Missile initiative and the Low-Altitude Navigation and Targeting Infrared for Night program's recent initiative to use its laser to capture MASINT data on attacked targets.

Communications Systems

A communications schema will be required to support the demands of each node of the assessment cycle. General characteristics of the nodes are given below:

- *Engagement*—Supports real-time information and assessment feedback. Seeker guidance and hit/miss criteria must be supported to the weapon or weapon system platform. Communications systems must transmit two-way data that are real-time, usually "small" packet size (<20k), and constructed to support a "binary" decision—shoot or don't shoot, engage or do not engage. Other communications supporting situation awareness, resource retasking, or mission reporting may be of larger size and not be as time sensitive. Data requiring interpretation are not appropriate at this level.
- *Mission*—Supports near–real time retasking of resources. This is the first level of force management, where value-added synthesis of information is required (that is, targets are associated with attacking assets and in support of the attack). Missions are retasked based on changing dynamics of the situation to meet needs in context of the strategy. Communications at

[7] See the SAB 1999 COTS Summer Study.

this level require larger “pipes” (1 to 10 megabits per second) depending on mission. A level of interpretation supported by fusion is appropriate at this level. However, automated tools that monitor, trigger, model, simulate, iterate, and track decisions are needed to facilitate the tempo and volume of work.

- *Force*—At this level non- and near–real time information is synthesized and fused to provide a picture of how well the campaign is meeting its intended objectives. The effects are weighed against the desired effects and end states, and retasking is accomplished to advance the end state. Large communications systems are required to support distributed collaboration, reachback, and “moving information, not people” as described in the EAF concept. Imagery files, distributed simulations and models, and live video feeds require bandwidth in excess of 100 Mbs. Vertical connectivity to engaged units in OOTCW will also be supported with real-time force management.

This report addresses the force management issues at the latter two levels of control (mission and engagement) and assumes integration of the engagement activity to assure consistency within the information exchange. For related concepts, see the 1999 Joint Battlespace InfoSphere Summer Study.

Networks

Networks and smart nodally configured systems (mission based) will be the backbone of the supported infosphere. Nodes will “sign on” and “sign off” the system seamlessly and change priority based on mission phase and need. See the SAB 1999 Joint Battlespace InfoSphere Summer Study.

Modeling and Simulation

Modeling and simulation are essential tools in the force management feedback loops, especially those for action and effect assessment. Identifying the set of actions needed to achieve the desired effects and then monitoring the execution through simulation of the actions taken are two ways in which models and simulations can be used. Recent advances in modeling, such as influence nets and executable models relating events to effects, allow the integration of intelligence models with operational models used in planning.

8.4.10 Interfaces

Interfaces must be developed so that exchange protocols (application program interfaces, messages, etc.) are at an unclassified (or releasable) level.

The effort to develop interfaces between TBMCS and other Service and non-DoD systems can be substantially improved by developing a technical architecture consistent with the Joint Technical Architecture. Specifically, the technical approach should implement a “minimum set of performance based primarily non-governmental standards needed to maximize interoperability and affordability.” As directed by Under Secretary of Defense Memorandum 30 November 1998, the technical interfaces and standards must be enforced and funded with an assigned responsibility to an individual or office.

8.4.11 Controller and Shooter Support

A linkage that is “shooter-friendly” needs to be established between the TBMCS and engagement-level systems (mission planning, in-flight auto routing, assessment) to reduce crew and mission preparation time and reduce errors in communications, targeting, etc.

A need exists to integrate force-level planning, mission planning, in-flight planning, assessment, and resource generation and regeneration systems. Eliminating entities that have unique entry and output systems, with their accompanying transposition errors and inefficient “vertical” integration, would

substantially improve timely force management. Functional integration of the vertical C^2 nodes should be a principal area of architecture development.

8.5 Communications Findings

The Air Force has not implemented an appropriate systems strategy for the communications architecture necessary for the 21st century in general, nor for the EAF concept. This lack of an appropriate overview is particularly acute for OOTCW preparations.

Providing the communications support for the Air Force EAF requires fundamentally different communications architectures than in the past, particularly with regard to OOTCW. The panel's findings are grouped into two general areas: first, providing the communications to enable EAF force units to engage in a carefully controlled real-time battlespace with extremely low risks of fratricide and collateral damage plus high assurance of force protection; second, providing the rapidly deployable communications to support AEFs worldwide and the backbone to allow split-base operations with reachback that make possible a small forward footprint.

8.5.1 Communications to EAF Units

The findings with regard to the first area, combat information, can be summarized as the Air Force's lack of a network-based architecture for combat information in a deployed status (AEF). The necessary feedback loops among information nodes, force units, platforms, and weapons to support low–fratricide, low-collateral damage strikes are not even considered, much less implemented.

Specific findings are as follows:

- Current Air Force fighters, including most F-15s and F-16s, do not have datalink connectivity
- Future 21st-century fighters, including the F-22 and Joint Strike Fighter, are not planned to have two-way connectivity with Air Force or joint information sources
- The superior sensors of the AC-130 and Air Force position-location information plus commercial air picture are not netted for force protection of the deployed force against asymmetric threats
- Communications to support direct imagery to the cockpit are not in place
- Inadequate attention is being paid by the Air Force to the ready access by potential adversaries to commercial, space-based systems and services for communication, remote sensing, and navigation

8.5.2 Deployable Communications

The finding with regard to demands of the EAF concept on communications support for both near–real time combat information and for planning information and logistics is that the concept of split-base operations places extraordinary demands upon communications deployability and capacity. The required communications connectivity and capacity are not being planned or implemented to support the Air Force Battlespace InfoSphere as defined by the SAB 1999 ad hoc study on this topic.

Specific findings are given below:

- Communications for support of EAF deployment depend on heavy, obsolete Tri-Service Tactical Communications equipment
- Deployed (and some in-garrison) squadron personnel lack modern connectivity such as cellular telephones, pagers, and other elements of connectivity and information support

- Even communications squadron personnel lack their "home-station" connectivity and information support when deployed. This reduces their ability to provide information support to the deploying units
- Commercial satellite communications services in all orbital regimes (low, medium, and geostationary Earth orbits) will provide the backbone of the future Air Force communications architecture
- Conformal phased-array antennas may allow satellite connectivity to aircraft at low sacrifice of aircraft performance
- Inadequate attention is being paid to planning for implementing remotely reprogrammable hardware and software units and systems
- The potential Air Force reliance on the commercial telecommunications and space sector for meaningful long-term R&D investments is unfounded and unrealistic

8.6 Communications—General Recommendations

Specific recommendations including suggested action relating to the communications are detailed in the following paragraphs.

8.6.1 Communications Architecture for Force Management

The communications and information systems and architectures must support the force management feedback loops. The three critical functions enabled by the force management feedback loops of "dynamic battle control," "action assessment," and "goal/effect assessment" are essential for OOTCW. Proper implementation of these supporting communications and information systems is required to provide C^2 performance within an adversary's planning and decision cycles.

The resulting communications architecture must meet the needs of each AEF for both MTW and OOTCW missions. The architecture must be flexible and modular to accommodate the specific mission requirements for each operation. Seamless interoperability must be achievable with coalition and joint, combined, or civil elements participating in MTW or OOTCW. The resulting architecture must be consistent with the Joint Battlespace InfoSphere.

This architecture must accommodate a significantly greater emphasis on the controller or shooter and integrate the controller or shooter as a critical consumer of direct, essential, timely information.

Develop a responsive, scalable communications architecture for the EAF.

8.6.2 Leverage Commercial Tools and Practices[8]

Leverage "state of the practice" commercial tools, services, infrastructure, and business practices to the maximum extent practical.

This will maximize cost-effectiveness, modularity, technology currency, and interoperability.

8.6.3 Field Automated Communications Planning Tools

Fielding of automated communications planning tools is essential to integrate operational elements critical to OOTCW mission success. There are two operational areas needing immediate integration of these highly leveraged enablers: first, develop and field communications planning tools that integrate the

[8] See the SAB 1999 COTS Summer Study.

Time-Phased Force Deployment Document generation process in order to integrate and coordinate C^2 and ISR functions critical to OOTCW missions. Second, develop and field tools that enable generation of the communications plan as an integral component of the ATO. This will save the additional planning cycle that is currently required to generate the mission communications plan after the initial ATO is defined. Additionally, constraints to potential ATO objectives due to availability of communications resources will be evident earlier in the planning process.

Adapt and field commercial communications systems planning tools for the generation of operational plans.

8.6.4 Establish Integrated Aircraft Communications Requirements and Architecture

Achieving meaningful, effective "information to the cockpit" must be an integral part of this requirements and architecture process. In addition to integrating legacy and future military communication capabilities, the emerging ready availability of robust commercial communications systems and services, operating at nonmilitary frequencies, should be included as a highly leveraged enabler. The requirements must include coalition operations that will use joint, combined, and civil resources.

It is critical to develop an operational radio frequency architecture as an integral component of the overall communication architecture. This is necessary to achieve assured communications with maximum availability, interoperability, and robustness.

Conduct a top-level requirements review for aircraft communications to generate a unified and integrated communications architecture.

8.6.5 Develop Remote Reprogrammability

Remotely reprogrammable aircraft units and systems reduce operator workload and increase communication reliability. For weapon systems, the technology allows near–real time updating of targeting information. Define an operational concept that includes automatic frequency selection in operating aircraft radios by the Airborne Warning and Control System (AWACS) and other control nodes. Define an operational concept that includes updating of weapon system parameters on operational aircraft by AWACS and other control nodes.

Define and develop remotely reprogrammable aircraft units and systems, including communications and weapons systems.

8.6.6 Define Integrated Aircraft Antenna Requirements

There is need to significantly simplify the suite of individual antennas currently employed on operational aircraft. The objective of this effort should be to achieve interoperability, coalition operations, and use of military and commercial satellite communications with a much smaller number of much higher-performance antennas than currently employed, as can be reasonably accomplished without introducing electromagnetic compatibility/electromagnetic interference problems. Properly done, realization of significantly increased link availability, bandwidth capacity, operating frequency range, and antenna beam agility should be realized, all with minimum aircraft performance impacts.

Determine requirements for and implement development of an integrated antenna suite for Air Force aircraft.

8.6.7 Synchronization of Interoperability for OOTCW

The interoperability of Air Force C^2 and ISR systems across stovepipes and with other Services and coalition partners, including civilian agencies that cannot handle classified information, ranges from very

limited to nonexistent. Broad interoperability between diverse systems is especially important in OOTCW. Interoperability databases and planning tools are being built elsewhere. The Air Force can gain from this experience and incorporate interoperability planning in the composition of the C^2 and ISR system of systems. Interoperability depends upon execution of related programs in a synchronized manner to obtain commonality of versions, updates, etc. Enforcement of interoperability may require authority to withhold or accelerate funding of individual system program management as done in the Army. Currently the AC2ISRC charter gives the Center the responsibility for ensuring interoperability only for conformance to standards required for joint certification. An internal Air Force process for synchronization with an enforcement mechanism is also needed.

Assign to the Chief Architect the responsibility and authority for interoperability standards and testing.

8.7 Conclusion

The Force Management Panel examined the force management process and communications that the Air Force needs to implement to enable it to carry out OOTCW using AEFs. A set of findings and recommendations for each area has been presented.

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Appendix 8A

Force Management Mission Statement

The tasking to the Force Management Panel was as follows:

- Identify mission planning and C^4 needs and issues unique to OOTCW
- Assess current and planned Air Force capabilities against these needs and the staff provided OOTCW vignettes
- Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
- Postulate [options] evolutionary and revolutionary concepts (materiel and tactics) and technologies for meeting these needs
- Determine needed changes in structure or organization that are needed
- Interface and coordinate closely with the Intelligence and Vigilance Panel

Provide primary interface between Summer Study and Gen McCarthy's Ad Hoc study (to include use of Summer Study derived concepts as test vignettes in the Ad Hoc study)

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Appendix 8B
Organizations Consulted

33rd Fighter Wing

Aerospace Command and Control, Intelligence, Surveillance and Reconnaissance Center

Air Combat Command

Network Operations Security Center

Air Force Command and Control Battlelab

Air Force Command and Control Training and Innovation Group

Air Force Experimentation Office

Air Force Information Warfare Center

Air Force Research Laboratory, Information Directorate

Air Force Special Operations Command

Air Intelligence Agency

Electronic Systems Center

Joint C^4ISR Battle Center

Joint Command and Control Warfare Center

Joint Warfighting Center

MITRE

U.S. Air Forces in Europe

U.S. Atlantic Command, J6 and J9 (now called U.S. Joint Forces Command)

U.S. Central Command

U.S. Special Operations Command

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Chapter 9

Experiments, Training, and Exercises

9.0 Introduction

The panel was organized to assess the need for experiments, training, and exercises (ETE) within the context of Operations Other Than Conventional War (OOTCW). The definitions of the needs considered under ETE are as follows:

- Experiments, defined by the classic scientific model, can be executed at any level with a variety of tools: tabletop tools, modeling and simulation or field experiments with logical analysis, computers, and live tests. The Air Force battlelabs are an ideal environment for testing potential improvements to Air Force operational concepts.[1] At a higher level of integration, the Air Force's new Joint Expeditionary Force Experiments (JEFXs) provide the opportunity for new technical and doctrinal assessment.
- Training, as one of the three major Air Force responsibilities outlined in Title 10 U.S. Code (that is, organize, train, and equip), includes instruction, which focuses on new knowledge; practice, which is the process of translating knowledge into skills; and rehearsal, which focuses on real-world practice of the operational scenarios soon to be executed. Training occurs at three levels—individual, team, and interteam.
- Exercises are planned events designed to demonstrate a capability at the individual, team, or interteam level. They can be simple, small-scale, local events or complex, large-scale, multi-Service or international events. The Air Force participates in Joint Chiefs of Staff (JCS) exercises, such as Roving Sands or United Endeavor, and holds its own exercises, for example, Red Flag or Cope Thunder. A major command (MAJCOM) example is U.S. Air Forces in Europe (USAFE), which participates in more than 50 exercises a year, including North Atlantic Treaty Organization (NATO) exercises, Partnership for Peace exercises, and bilateral exercises.

9.0.1 Operational Context

The motivation for considering ETE as a part of this study derives directly from Air Force requirements for Global Engagement Operations (GEO), within which OOTCW are a significant part. A sampling of specific GEO phases and respective elements in which ETE requirements are embedded is summarized in Table 9-1.

[1] Air Force Scientific Advisory Board study, *United States Air Force Expeditionary Forces*, Volume 2, Appendix E, February 1998.

Table 9-1. *Global Engagement Operation Elements for Readiness*[2]

GEO Phase	***Element Related to Experiments, Training, and Exercises***
Shape	Maintain readiness, home defense, and deterrence through aerospace power
Respond/Deter	Respond rapidly with forward and home-based Aerospace Expeditionary Forces and arrive ready to execute the mission
Respond/Halt	Find, fix, track, target, and engage anything significant in near–real time and assess effects
Respond/Win	Enforce political, economic, and military sanctions with aerospace power
Reshape	Enhance post-crisis stability with skilled and motivated airmen Sustain heightened readiness to react decisively to renewed crisis

9.1 Approach

Almost all functions and forces involved in Air Force missions and OOTCW—that is, combat forces, airlift, command, control, communications, computer, intelligence, surveillance, and reconnaissance (C^4ISR), installation logistics, force protection, medical, and space forces—were considered in the context of ETE. Findings and recommendations are the result of an information-gathering effort supplemented by considerable discussion among panel members and consultants to reach consensus. Specific technical findings were based on initial panel assessments augmented by contributors from Stanford University and Sandia National Laboratories.

9.2 The Current State of Exercises, Training, and Experiments for OOTCW

The need for effective approaches for ETE is evident when one considers the broad range of OOTCW missions that can combine force elements into tasks, at relative levels and with constraints atypical of major theater war (MTW). For example, in the context of this study's Somalia 2010 vignette, the gradually escalating nature of the scenario delays the introduction of combat forces early on except for limited defensive purposes. The need for tight integration of airlift with intelligence, surveillance, and reconnaissance (ISR) resources to get supplies to the intended recipients and to conduct evacuations quickly and securely dominates the mission requirements. As the events of the scenario escalate, additional specialized missions are introduced in concert with limited engagement requirements to produce an extremely complex force employment and coordination environment.

In addition to the variability and potential complexity of the OOTCW mission space, the current acquisition and operational environment introduces other issues and constraints for applying ETE to OOTCW. Declining budgets have squeezed resources available for range exercises and unit training. Equipment and personnel are being overtasked by deployments and increasing operational tempo (OPTEMPO), further eroding the opportunities for training and exercises. Live practice with modern weapon systems is limited because of their extended range as well as for safety and security. In the middle of these issues is the introduction of the new operational concept of the Expeditionary Aerospace Force (EAF), with its distributed Aerospace Expeditionary Force (AEF) elements having to learn to function as a team.

The consideration of all these aspects for ETE has motivated an evaluation of the potential of simulation-based capabilities to enhance current individual and unit training and exercises, as well as experiments. Improved simulated training environments, when combined with current training practices, should help to manage the complexity, constraints, and personnel considerations that would otherwise make ETE for

[2] Elements from MGen Don Cook, USAF, "USAF GEO Supporting the National Military Strategy," June 1999.

OOTCW practically impossible. In addition, low-impact modifications to current education, experiment, and exercise programs in both the Air Force and U.S. Atlantic Command[3] (USACOM) have been assessed.

9.3 Major Findings

9.3.1 Summary

The ETE Panel had three major findings:

- The Air Force as an institution is giving little or no attention to OOTCW in ETE
- There is a need for distributed mission team training to enable OOTCW, and recent technology advances in modeling, simulation, and networking can significantly augment such training
  - The Army, Navy, and USACOM are more experienced and appear better integrated than the Air Force in moving to simulation-based ETE
  - Air Combat Command (ACC) has taken the initiative for distributed mission training (DMT), but there are multiple pockets of related simulation efforts and expertise within the Air Force, which are, by and large, not integrated
- Consistent with the institutional "back burner" status of OOTCW, current Air Force ETE doctrine, and education do not address OOTCW in a manner balanced with the dominance of these missions in current and future Air Force operations

9.3.2 Detailed Findings

Institutional Issues

The overall finding that influences the more specific findings discussed below is that there is little to no institutional attention in the Air Force to ETE needs for OOTCW. Given the context for training and exercises described in Section 9.2, this comes as no surprise since readiness requirements for MTW missions are increasingly difficult to meet, let alone with the additional factors introduced by OOTCW. This extends from professional military education (PME) through wargaming, training, and exercises. The Air Force doctrine for OOTCW is being redrafted to be more comprehensive and relevant. OOTCW is in the curricula of PME programs but should receive more emphasis. There is awareness in some major programs and at least one MAJCOM that the situation needs to shift. For example, Blue Flag exercise 99-4 planned for September 1999 starts with a noncombatant evacuation operation escalating to a halt phase, then to a major conflict. Also, JEFX-99 will include a humanitarian medical relief vignette based on a biological or chemical event. The most significant shift in focus has taken place at USAFE where its NATO and bilateral exercises increasingly emphasize combined force operations important for OOTCW. In preparing for EAF operations, USAFE is planning a major exercise in Cameroon in spring 2000 that will address almost all phases of OOTCW up to a major conflict threshold. Each of these examples, however, represents a separate and limited initiative as opposed to a unified Air Force strategy.

Distributed Mission Training

Overview. To enable the EAF to address the broad OOTCW mission space, there is a need for distributed mission team and interteam training, experiments, and exercises. Modeling and simulation can play a large role in meeting this need. An assessment of task training for individual force elements suggests that current practices are adequate because MTW and OOTCW operations at the task level are very similar. At the operational level, where the individual force elements are combined, training and

[3] Now called U.S. Joint Forces Command (USJFCOM).

rehearsal opportunities are all but nonexistent. The most promising enabler, besides live training, for meeting the mission readiness needs for OOTCW and MTW appears to be the DMT concept. DMT would provide a fully integrated simulation environment tying together geographically dispersed force elements—combat, airlift, command and control (C^2), ISR assets, installation logistics, force protection, etc.—in a common and correlated synthetic environment to allow mission training in numerous scenarios beyond those afforded by live exercises and to support mission rehearsal. In addition, DMT would augment live training to make limited live opportunities more effective.

DMT is intended to be a shared training environment comprising live, virtual, and constructive assets that allow warfighters to train individually or collectively at all levels of war. It will allow multiple players at multiple sites to engage in training scenarios ranging from individual and team participation to full theater-level conflict. It will enable nearly unlimited training opportunities for joint and combined forces from their own location or at a deployed training site. This expanded capability should provide on-demand, realistic training opportunities for all Air Force operators unconstrained by the fiscal, geopolitical, legal, and scheduling problems associated with current real-world ranges and training exercises that limit training effectiveness and arbitrarily cap readiness levels. DMT could dramatically improve the quality and quantity of training. With the advent of low-cost, high-fidelity, unit-level simulators with full visual systems, the warfighter will be immersed in the training arena or "global synthetic battlespace." Ideally, units could network with other air, ground, sea, and space forces to execute the air tasking order (ATO) in a specific training scenario developed and managed by respective battle staffs.

Motivation for DMT. The advantages of DMT are numerous. The simulation environment allows a timely and cost-effective means for addressing a wide variety of missions and permits undertaking operations not possible in live exercises. The distributed architecture provides a "stay at home" feature to relieve OPTEMPO demands and offers the ability to draw from common databases to present reasonable facsimiles of the mission environment to all players. Pushed to its full potential, DMT will enable mission rehearsal in predeployment, en route, and deployed situations. Probably the most important feature of DMT is the opportunity it affords for development of interteam skills among heterogeneous and geographically dispersed mission elements characteristic of an AEF.

Moreover, it has been shown that individuals provided with mission training simulation are able to perform much more effectively in the live environment. One recent Joint Task Force (JTF) evaluated all phases of integrated Joint Combat Search and Rescue (JCSAR) and used virtual simulation as part of its efforts. The virtual simulation exercises proved more suitable for training than live testing. Virtual simulation provided similar results to field tests while allowing more variations on a scenario to be explored, and aircrew participants were enthusiastic about its potential. A recommendation from the JTF was for the Services to use the virtual exercise concept to complement live exercise training.

Legacy studies have also proven the value of simulated environments in training. In-simulator learning studies sponsored by the Air Force and Navy during the past 30 years have demonstrated significant improvements in flight performance as a function of simulator training and have proven the value of combining tasks into realistic and complex scenarios to enhance training.[4] Other studies have also shown unequivocally that 6-degree-of-freedom platform motion capability, incorporated in many legacy systems, does not enhance the training value of the simulator. It is believed that a "g-seat" and g-suit, along with stick and pedal shakers, provide all the necessary motion cues (at significant cost savings). The most

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[4] Maj. K. A. Seaman, *Improving F-15C Air Combat Training With Distributed Mission Training Advanced Simulation*, Air University, Maxwell AFB, AL, April 1999.

important factor contributing to performance enhancement is the fidelity of the visuals and cockpit controls and displays.[5]

Current Distributed Simulation Efforts. In October 1998, ACC took the lead in developing an Air Force–wide DMT Capstone Requirements Document which was coordinated by all MAJCOMs. To date, two Operational Requirements Documents (ORDs) have been generated—one from Air Mobility Command (AMC) and the other from ACC. ACC has begun to populate an Aircrew Distributed Mission Training (DMT-A) system with F-15 simulators that will have the ability to be linked with an Airborne Warning and Control System (AWACS) simulator. Future plans call for similar linked simulators for ACC's other combat platforms. In addition, AMC is starting to introduce its current simulators into the DMT environment. The addition and integration of other force elements—C^4ISR assets, logistics, force protection, medical, etc.—has not yet been seriously undertaken.

ACC should be commended for its initiative. However, there is no formal approach for leveraging or integrating existing capabilities and initiatives resident in the Air Force or sister Services. Following are some current capabilities and initiatives that offer important leveraging opportunities:

The Air Force Research Laboratory Warfighter Training Research Division (AFRL/HEA), in conjunction with the Training Systems Product Group, is collaborating with the Navy, the Marine Corps, the Air Force MAJCOMs, the Air National Guard, and industry to develop technologies and improved training methods and directly transition them to the user. Training enhancements will be developed and validated in the DMT testbed or on fielded systems. AFRL/HEA has produced numerous trainers and developmental equipment. Two are noteworthy: (1) a mobile modular display for advanced research and technology (M2DART) and (2) a multitask trainer (MTT) and unit-level trainer for A-10, F-16, and C-130 aircraft. The M2DART system, which was designed to replace simulator domes, is significantly brighter than previous domed systems. It has a head tracking system that reduces the number of live video channels required and covers all channels without compromising pilot performance or limiting the field of view. MTT technology has proven successful: tests show that the F-16 MTT can be dismantled quickly, fit in any squadron setting, and accompany a unit to a deployment zone. The panel did not see how these advances were making their way into the new simulators being leased by ACC.

The 58th Special Operations Wing at Kirtland Air Force Base (AFB) has linked its helicopter, virtual-reality gunner's position, and fixed-wing aircraft simulators to provide training and mission rehearsal capabilities for special operations forces.

The unique Theater Air Command and Control Simulation Facility (TACCSF) has high-fidelity warfighters in the loop with tactical C^2 assets operating in a simulated environment.

Of equal importance are the efforts in the Army and Navy and at USACOM that offer significant opportunities for leveraging investments and for mitigating interoperability problems as the simulation environment merges to become more joint. Following are some examples:

The U.S. Army Training and Doctrine Command is introducing One Semi-Automated Force (OneSAF), a second-generation synthetic battlespace force training and exercise capability. OneSAF draws on technologies and databases developed in Defense Advanced Research Projects Agency's (DARPA's) Synthetic Theater of War (STOW) program and is forming the basis for co-investment by the Navy and Marines to develop a "JointSAF" common battlespace. A yet-to-be-answered question for the semi-automated force (SAF) family and related battlespace models is how the object representations will be formally verified, validated, and accredited to ensure consistency among all players.

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[5] Dr. T. A. Gray and Maj. R. F. Fuller, *Simulator Training and Platform Motion in Air-to-Surface Weapon Delivery Training*, Flying Training Division, Air Force Human Resources Laboratory, Williams AFB, AZ, undated.

The U.S. Navy introduced its first Battle Force Tactical Training (BFTT) system in 1997. BFTT is an in-port (to be evolved to at-sea) shipboard combat systems team training capability that supports unit-level to battlegroup team training through synthetic stimulation of the shipboard sensors and simulation of all other forces in the battlespace.

Naval air has already linked F-14, F/A-18, and E-2C flight simulators for mission training.

At a higher level of command and integration, joint operations are practiced and doctrine developed in simulation-supported environments at USACOM. The most recent program introduced at USACOM is the Joint Experimentation Program to assess new concepts and capabilities for realizing *Joint Vision 2010 (JV2010).*

The Joint Advanced Distributed Simulation (JADS) JTF performed an end-to-end test to examine the utility of advanced distributed simulation (ADS) in C^4ISR testing by introducing ADS into developmental and operational test and evaluation of the Joint Surveillance, Target, and Attack Radar System (JointSTARS). This activity included laboratory developmental and operational testing, ADS integration onto an E-8C, and operational testing with a live E-8C. The results indicate that ADS has high utility for C^4ISR testing and that test environments can be transitioned to distributed training environments. Specific benefits are cost savings, affordable test assets, reproducible high-confidence test results, and high virtual sortie rates.

Figure 9-1 depicts the large number of distributed simulator efforts identified during this study. Some of these efforts are linked by communications lines or at least by knowledge sharing. The ETE Panel is confident that there are other capabilities that were not identified.

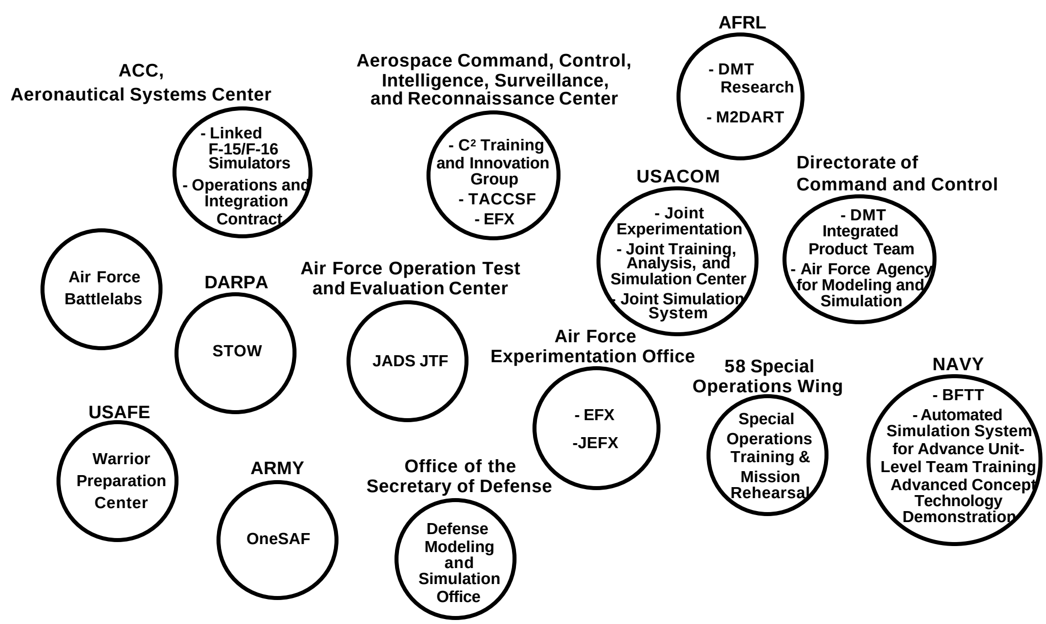

Figure 9-1. *Current DoD Distributed Simulation Efforts*

Organizational Issues for DMT. The current ACC planning and resource commitment for DMT extends only to aircrew training and is being called DMT-A to denote its scope. As noted above, ACC jump started DMT with DMT-A, but the limits on what the command can initiate rapidly have introduced some potential downstream problems. The current DMT-A acquisition plan and operation and integration concept are not robust enough to be (nor were they intended to be) a proxy Air Force–wide acquisition

strategy and integration architecture. The development and use of new simulators is being handled by individual fee-for-service contracts for each airframe, and as such, funding comes out of operations and maintenance accounts versus acquisition accounts, the former being highly vulnerable to overriding operational disruptions such as a Kosovo startup.

Integration of different airframes is starting to be addressed through Aeronautical Systems Center, Training Systems Product Group (ASC/YW) efforts to select an operations and integration contractor to work on the first two simulator platforms (F-15 and F-16) being developed. However, the process did not start with an overall architecture, and hence integration is expected to encounter any number of simulator interoperability problems. For example, the fee-for-service arrangement for the ACC simulators does not permit specification of the battlespace environment to the contractor, making qualification testing of the underlying models impossible and correlation between different simulator platforms problematic. In contrast the AMC approach is acquisition based, giving Air Force evaluators full access to the contributing modules. However, affordability is dictating that AMC upgrade its legacy systems, which another study panel has found to be inadequate for effective training (see Section 9.4.3).

Moving beyond DMT-A, the DMT Capstone Requirements Document developed by ACC has not yet led to an Air Force-wide integrating architecture, roadmap, or acquisition plan. A newly formed Integrated Product Team (IPT) for DMT is hoping to address many of these issues and enjoys participation from not just ACC and AMC representatives but also all the major Air Force commands, and policy and implementation offices. However, the user participants outside of ACC and AMC have no resource commitments, and Deputy Chief of Staff, Air and Space Operations (AF/XO) and Assistant Secretary of the Air Force, Acquisition (SAF/AQ) have no clear champions in senior leadership enforcing integration.

Technical Aspects of DMT. Though the promise is great for DMT, several technical problems remain unsolved. Given adequate funding, however, there appear to be no technical barriers to the development and deployment of effective DMT. The areas needing technical solutions include:

- **Developing adequate and timely information for the synthetic environment.** A cost-effective capability is needed to update database terrain, three dimensional (3-D) objects, and models with (1) data from more geographic areas in order to train effectively in a variety of locations, (2) timely data in order to simulate missions in new areas on short notice, (3) real-time alterations to database information to account for events during simulation, and (4) real-time or near-real time, alterations to database information to incorporate mission information, such as real-world imagery.
- **Representation of effective threat and response environments.** A realistic representation of threats is essential to simulator effectiveness. Current modeling and simulations generally include some randomness in weather and terrain but seldom other uncertainties. Uncertainties about technical and human performances on both friendly and opposing sides are an essential part of battlefield operations. They are particularly critical for the planning of complex operations involving many systems and interfaces. The challenge is not only in the analytical treatment of these uncertainties but also in the physical representation of their effects on the results. Furthermore, the performance rating system of simulator trainees must include their responses to risks and uncertainties, and the rating decisions must represent what commanders want to see on the battlefield.
- **Incorporating joint capability to accommodate the nature of MTW and OOTCW.** This entails both development of and adherence to standards, as well as participation in multi-Service and joint advanced concept technology demonstrations (ACTDs), experiments, and exercises.
- **Understanding and accommodating network latencies.** Characterization and compensation for network latencies that otherwise degrade distributed training effectiveness is critical to DMT implementation and acceptance. Tools such as time stamping and event correlation for the

synthetic elements in a DMT exercise and STOW's distributed data management algorithms that enable tailored data packet transmission in the high-level architecture (HLA) environment could help.

- **Providing security.** Realistic mission simulation both within the Air Force and among multi-Service, joint, or coalition organizations requires a network security system that enforces both multilevel security (MLS) and need-to-know (NTK). Development and accreditation of such a system will enable realistic DMT, contribute to solving the network latency issues, and impact applications well beyond DMT.
- **Improving standards for DMT.** Migration to HLA is important to ensure interoperability of all players and simultaneous evolution of HLA's protocols to enable accurate data transmission, to address latency and security issues, and to drive HLA to a more accepted and robust architecture. HLA is in its infancy compared to the distributed interactive simulation (DIS) standard. As such, many problems in distributed applications remain. However, its fundamental multicast architecture offers a more effective alternative to the DIS broadcast protocol for addressing latency and MLS and NTK issues.

To make DMT a reality, many of the present enabling technologies must be significantly improved and made affordable, and some new concepts must be developed into usable technologies. While low-cost, high-fidelity cockpits are available, these devices must now become surrogate weapon systems rather than superficial emulations that merely complement the aircraft. Practical interfaces from the virtual systems to the live or real systems must be developed. Visual and cueing systems must adequately represent the environment to allow the players to execute their missions. Networking requirements include local area and long haul or wide area, and these networks face MLS challenges to reliably connect disparate sites around the world. Network interface units and simulation communications protocols (for example, DIS and HLA) must be expanded to accommodate massive amounts of information and traffic generated by thousands of entities. Mission control stations, threat systems, and mission support stations must be improved and standardized to provide mission planning coordination and execution capabilities to the warfighters. Technologies are being advanced to create affordable solutions for these training nodes, effectively reducing the cost of a four-ship system, for example, from hundreds of millions of dollars to less than $20 million.

Current Experiments, Training, Exercises, Doctrine, and Education

Overview. History and current trends clearly indicate the growing roles for the Air Force in OOTCW. Integration of OOTCW throughout the spectrum of ETE doctrine and education is still by exception, however, and needs to be addressed.

Expeditionary Force Experiments (EFXs). In 1998, the Air Force began a new program, EFX. Its purpose is to develop new operational concepts aided by the introduction of new technologies. The program combines live fly and simulations in a realistic, seamless warfighting environment. The operational concepts and technologies deemed worthy from an experiment are then expected to rapidly evolve and mature into new processes, concepts, and capabilities for warfighters. The program was originally designed to have an experiment yearly, but after 2000 it will shift to every other year in order to more carefully evaluate and transition experiment results. Originally an Air Force-only program, it is starting to include joint elements with unified command and other Service participation and is now known as JEFX.

The first EFX in 1998 had no OOTCW "play." JEFX-99 plans on using an OOTCW initial phase as an experiment within an experiment to look at escalating scenarios for future JEFX efforts. This experiment is based on a medical relief mission in Africa. The 3rd Air Force commander operating out of Ramstein will serve as the Joint Forces Air Component Commander (JFACC). The scenario then escalates and shifts focus to Korea (Ulchi Focus Lens). The full-employment phase is based on live-fly operations in a

conventional war scenario. JEFX-2000, now in the planning stage, may contain a limited OOTCW scenario in the beginning but is planned to move quickly to conventional warfighting operations.

EFX offers an important opportunity to the Air Force for evaluating both new concept of operations (CONOPS) and emerging technologies. There is not, however, a clear transitional process for moving from JEFX findings and recommendations to new technology insertion programs or doctrine changes within the Air Force. The Air Force Experimentation Office (AFEO) is charged to "incorporate a process that translates insights for experiments into the Air Force Strategic Plan, Air Force requirements, and fielding of future Air Force/Joint capabilities."[6] That charge has yet to mature into a well-understood and -implemented process.

Flag Exercises. The Air Force Red and Blue Flag exercises are excellent vehicles to train but have not yet routinely incorporated the OOTCW mission space into their scenarios. Since its inception in 1975, Red Flag (live-fly training exercises held on the Nellis range complex) has focused almost exclusively on large-scale composite force training, with emphasis on interdiction, close air support, suppression of enemy air defenses, and offensive and defensive counterair. Although the tasks associated with these missions would help in certain OOTCW situations, they have not been flown in the context of OOTCW. Rather, an MTW is generally the setting for these exercises. Similarly, Blue Flag (computer-assisted exercises [CAXs] designed to provide training in C^2 of forces in a realistic warfare scenario) has focused on current operation plans. Blue Flag exercises normally start at the halt phase of these major plans, and the scenarios end after major conflict has started. Both Red and Blue Flag exercises are beginning to consider OOTCW missions by initiating smaller-scale events that escalate to MTW. However, integration of OOTCW into flag planning and scenarios is not routine.

Joint Experimentation. USACOM, through its Joint Training and Doctrine Program, is assigned leadership for OOTCW doctrine development. USACOM is also the office of primary responsibility (OPR) for the Joint Experimentation Program. This program emphasizes transformation and innovation, where ideas for both MTW operations and OOTCW in the joint environment can be wrung out. The Joint Experimentation Program will participate in JEFX-2000 and expects to be a full joint partner in future JEFX efforts. The Joint Experimentation Program is relatively immature, having been initiated in October 1998. This provides the Air Force with an opportunity for influencing and leveraging areas of focus.

Air Force Doctrine for OOTCW. The current Air Force Doctrine Document (AFDD 2-3) regarding military operations other than war (MOOTW) was written in 1996. According to the Air Force Doctrine Center OPR for MOOTW, the document was hastily constructed and does not represent current Air Force thinking. A new version has been drafted and by the time of publication of this report, should be approved.

Professional Military Education. A quick look into the curricula of Air University indicates that courses addressing OOTCW are not prevalent. Although the Air University staff stated that OOTCW was addressed at each biannual curriculum review, it appears that more attention could be paid to this subject throughout the Air University educational system.

9.4 Recommendations

The panel findings resulted in two major recommendations:

1. Create a Distributed Mission Readiness System (DMRS) built on the DMT concept. Success requires solving (a) the technical problems, particularly those relating to MLS and NTK, latency, and behavioral models, and (b) the organizational issues related to ownership and integration.

[6] Col. Terry Thomspon, USAF, briefing to the ETE Panel, March 1999.

2. Integrate OOTCW more completely into ETE doctrine and education.

A third set of recommendations pertinent to ETE is found in Section 9.4.3 and was made by the other panels in this study.

9.4.1 Distributed Mission Readiness System

Recommendation: Create a DMRS from the DMT concept.

The DMRS vision, when coupled with training in the live environment, is a robust and flexible Air Force–wide capability that integrates all force elements into a combined constructive, virtual, and real environment that will prepare an AEF for full-spectrum global engagement. A successful DMRS will enable the manifestation of "train the way you fight," with fully mission-prepared units arriving ready to execute the mission on the first day. The recommendation to move from the name "DMT" to "DMRS" is intended to embolden the vision and to carry the DMT concept to its full potential to support not just training but also test, experimentation, and mission readiness. DMRS also expands the DMT concept to one that is not just combat-centric (the driver for the DMT Capstone Requirements Document) but embraces combat enablers, which may be the critical elements in OOTCW, and other components such as medical and force protection as integral parts of the readiness picture. Finally, DMRS builds the foundation for unifying all of the individual DMT and simulation efforts Air Force–wide and ensuring joint integration.

Figure 9-2 depicts the panel's vision of DMRS. The components include individual simulators and databases from across the Air Force in all mission areas (for example, airlift, combat, force protection, C^4ISR, installation logistics, and medical). Individual simulators at each wing are combined into mission training centers that provide independent mission planning, mission execution, and replaying and debriefing. The heart of the system is the DMRS Control Center, which establishes the network architecture and standards and maintains the weather, the Red, and Blue forces and entity models, and terrain databases. More important, the DMRS Control Center creates the synthetic environments for one or several simultaneous mission scenarios by integrating the simulators with models and databases, updated, when appropriate, with real-world data from ISR sources.

Distributed Mission Readiness System (DMRS) Vision

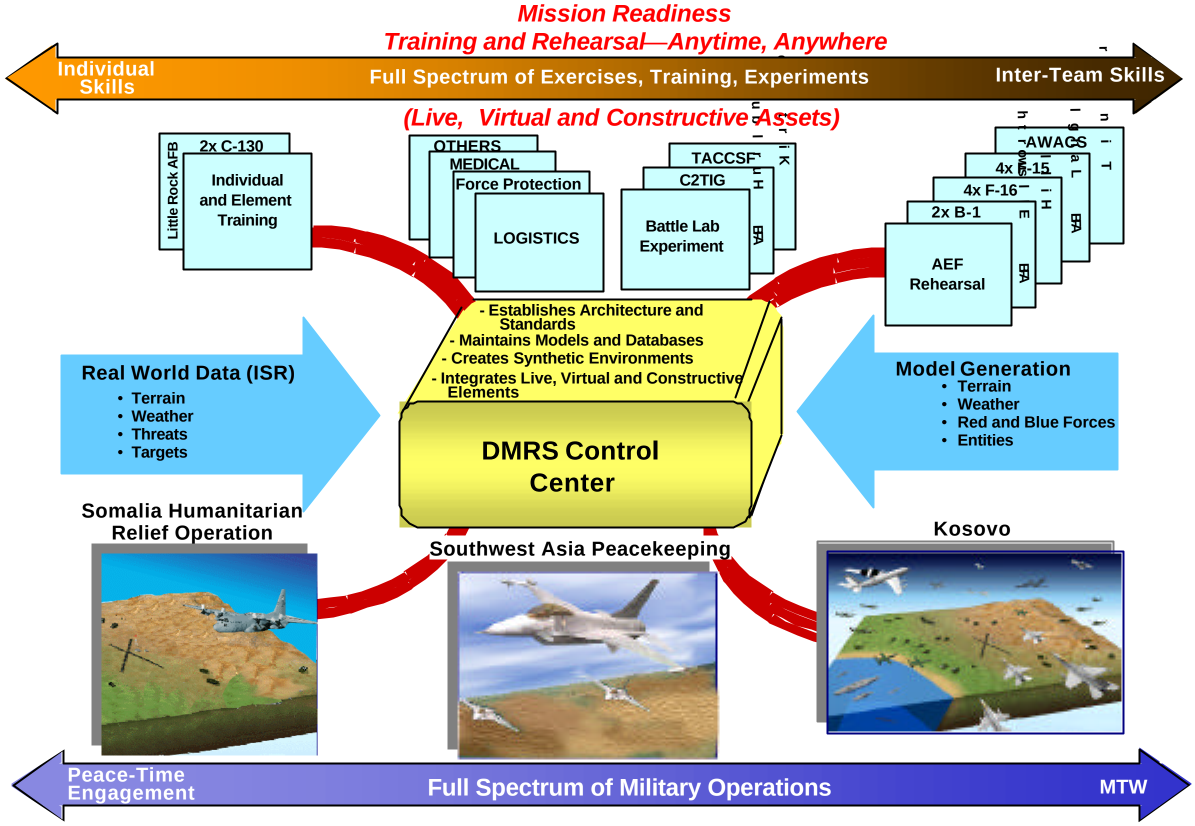

Figure 9-2. *Vision for the Distributed Mission Readiness System*

Specifics Associated With the DMRS Recommendation

A. Establish Air Force ownership for DMRS in the office of AF/XO and incorporate DMRS in Air Force plans by establishing formal requirement documents. This ambitious vision is realizable over the next decade if the organizational issues are addressed. The first step in creating the DMRS vision is to establish overall Air Force leadership. AF/XO, with its operational, technical, and resources staff, is the obvious choice for DMRS leadership. Once leadership is established, the first charge should be to implement the DMT Capstone Requirements Document and expand it to the full DMRS scope. In partnership with the Deputy Chief of Staff, Plans and Programs and the MAJCOMs, AF/XO should incorporate DMRS into Air Force plans and establish formal requirements documents that integrate the needs of all the MAJCOMs while ensuring interoperability of all the pieces and joint integration.

B. Establish DMRS as a major weapon system program within the Air Force. This recommendation is supported by several factors: the integration task underpinning the success of DMRS, the limited affordability among the MAJCOMs, the disconnect between ACC and AMC DMT strategies, and the vulnerability of the operations and maintenance budget that funds DMT-A for ACC. Establishing DMRS as a major weapon system program within the Air Force will ensure its proper resourcing and timely development and implementation.

C. Establish a DMRS formal acquisition strategy and force management plan and appoint a Program Element Monitor (PEM) in AQ. A formal acquisition strategy and force management plan

should be developed by the Assistant Secretary of the Air Force, Acquisition, a PEM should be appointed, and a DMRS system program office (SPO) should be stood up. The SPO should develop an Air Force–wide DMRS architecture, roadmap, and acquisition plan. It should develop, incorporate, and accredit MLS and NTK processes, solve the latency issues, and incorporate realistic behavioral models. It should leverage other Service programs and DARPA's STOW program.

D. Accelerate funding to develop and deploy DMRS, to include acquiring or modifying modular, cost-effective unit-level simulators. The goal of DMRS should be the same as DMT—to provide cost-effective, unconstrained mission training at the unit level. DMRS should integrate three types of devices: (1) virtual—person-in-the-loop simulation; (2) constructive—computer-generated forces, targets, etc.; and (3) real or live—actual hardware with an operator.

DMRS should be a high-definition simulation to

- Provide realistic joint mission training
- Provide cost effectiveness, including reasonable flexibility and upgradability
- Provide realistic threat, terrain, and event databases and models
- Minimize latencies
- Provide NTK security and MLS
- Promote standardization and scalability
- Provide realistic, high-definition visual systems

Fleshing these goals out more fully, the Air Force should do the following:

- **Maintain the priority of current AMC and ACC-ASC/YW DMT efforts and integrate them into the DMRS program.** The current DMT-A efforts should remain a high priority. Successful development of DMT-A will provide a valuable basis and bridge into the broader DMRS program (which itself should be phased to bring incremental capabilities toward the end goal).

- **Develop and mandate joint mission training and use the Automated Simulation Systems for Advanced Unit-Level Team Training (ASSAULTT) ACTD as a major step to that end.** DMT-A and its more fully realized successor DMRS will be valuable in their own right. Without joint capability, however, DMRS will have limited utility because (1) actual combat missions will invariably be joint missions and (2) while standardization efforts are under way (see below), there remains a danger of developing incompatible systems between different Services, particularly with respect to control centers and distributed databases and models. There appear to be no technical difficulties in providing the desired joint capability.

  An excellent opportunity for starting this process is the new ASSAULTT ACTD being planned under the leadership of the Navy. The ACTD is intended to fill a major DoD void by providing a comprehensive capability for joint-unit-level, objective training while allowing commanders in chief (CINCs) and subordinate commands to quantitatively measure the results. To help quantify training, the ASSAULTT ACTD will provide each Service with a common architecture for built-in training aids, metrics, and debriefing tools. Service interoperability will be achieved by establishing standards for and unifying the synthetic battlespaces used to drive virtual trainers. An added benefit of the ASSAULTT ACTD is a joint mission-rehearsal capability, which can allow for "just in time" training. The ASSAULTT ACTD offers significant leveraging advantages and learning opportunities for DMT and its evolution to DMRS. The Air Force should endorse and actively participate in the ASSAULTT ACTD.

- **Develop a cost-effective capability to update database terrain, 3-D objects, and models.** Databases, 3-D objects, and models should be improved with (1) data from more geographic

areas in order to train effectively in a variety of locations, (2) timely data in order to simulate missions in new areas on short notice, (3) real-time alterations to database information to account for events during a simulation, and (4) real-time or near–real time alterations to database information to incorporate mission information during simulation, such as real-world imagery.

The panel believes that much is to be gained by the Air Force if it joins with the other Services in the development of the common synthetic battlespace evolving from OneSAF into JointSAF and in tackling the deficiencies in HLA to support it. A major effort should be engaged by the Air Force Agency for Modeling and Simulation (AFAMS) to develop the SAF verification and validation process to ensure a common basis for synthetic battlespaces for all Air Force ETE programs, not just DMT and DMRS. Importing key STOW technologies should also be assessed.

- **Characterize and accommodate DMRS network latencies.** Simulation latencies do not appear to be a significant problem. Network latencies, on the other hand, are not well characterized and appear to be significant enough that without compensation, training will likely be adversely affected.

  The state of the art in simulation latency around 10 years ago was approximately 50 milliseconds (ms) for writing the visual display. For high-gain tasks, such as certain fighter aircraft tasks, this latency may either create instability in the simulation or mask an instability that is present in the real system. While AFRL/HEA personnel indicated that they are very sensitive to this delay and that current latencies are "much less than 50 ms," they could not specify what the latencies actually are. For task training in some fighter aircraft, this may remain significant. However, for *mission* training, the latency in the visual display may not be a significant problem.

  The AFRL/HEA has limited experience using DMT over wide areas. Its simulations use dedicated T-1 lines, and the latency is described as a "real problem." AFRL/HEA is working toward lowering the network latency to less than 100 ms, but even at this level, the latency is significant. AFRL/HEA does not yet know the full effect of this on DMT. 100-ms latency is significant enough that a missile shot accurately by one pilot in a simulator at one location may miss the targeted aircraft when that aircraft is being simulated at a significant physical distance. The same problem may occur in other tasks, such as bomb deliveries, use of guns, and simulation of threats. Given proper funding, this problem appears to be solvable through some technique to time-stamp and correlate events, assuming that the devices are virtual or constructive. This may require modification of DIS and HLA standards (see the standardization below). If a simulation includes real or live devices, however, time stamps and correlation may not be a feasible solution.

- **Develop, incorporate, and accredit DMRS NTK security and multilevel security.** Some data in simulations will be classified, such as aircraft performance parameters, mission tactics, and threat performance. Security for this information must be provided. The current implementation of security in DMT is to have all devices operate at the "high side" of classification. Traffic between simulators is encrypted on dedicated T-1 lines (at the network layer), with all traffic being sent to all simulators. This approach is adequate only for limited, single-Service simulations and becomes both undesirable and impractical for more extensive (and realistic) mission simulations. For example, the mix of aircraft in a real mission might include F-15, F-16, F-117, F-14, F-18, AWACS, HH-53, and KC-135 assets, which represent different Services and commands. In addition, some missions include foreign countries. It is undesirable to have all performance parameters, mission tactics, and threat performances from these individual systems shared with each other through a simulation, as well as impractical with current or expected bandwidths and system latencies.

  A security system that enforces both NTK and MLS is required. A system that provides only MLS (assuming this could be made available) would not be sufficient for this purpose, since all

simulators operating at the same classification level (such as Secret) would receive all traffic at that classification level, regardless of NTK. Neither an NTK nor an MLS system has been implemented in any distributed simulation as far as the panel could determine, although the Department of Energy weapons laboratories are working on this problem. AFRL/HEA personnel believe they could provide this capability through some system to label and then filter packets, but they appear not to have funds to develop this. Accreditation of such a system would be difficult, although AFRL/HEA personnel believe that, with funding, they could field a B-2 or B-3 level accredited product within 2 years. The panel views the technical and policy issues as significant, and the development may be more difficult than AFRL/HEA personnel currently believe. A satisfactory solution to this problem, however, will have applications well beyond DMT and DMRS.

- **Promote improvements to DIS and HLA to increase flexibility, reduce bandwidth, account for latency, and provide NTK security and MLS.** Two standards for distributed simulation have been developed through periodic workshops in Orlando, FL, since about 1990. The first is the DIS, Institute of Electrical and Electronics Engineers Std. 1278.3-1996, which provides guidance to "assure interoperability between dissimilar simulations for currently installed and future simulations developed by different organizations." DIS-compliant simulators each have a network interface unit, which sends protocol data units (PDUs), using the user datagram protocol (versus the transmission control protocol or Internet protocol). PDUs contain that simulator's state information and other variables. This standard is apparently well accepted and functional, but because PDUs are sent continuously to every other simulator, DIS does not scale. This is due to bandwidth requirements resulting from different simulations being conducted over the same network simultaneously or large simulations connecting many devices.

  To address the bandwidth problem, HLA has been under development since 1997. Although it is promoted as "not a standard" (for reasons not understood by the panel), it appears that it will and probably should function as one. The HLA "standard" builds on DIS by establishing federation object models. Under HLA, in order to participate in a simulation, the user must join a "federation" prior to the start of the simulation. Devices in the federation send PDUs only to other entities of interest within the federation. To substitute one simulator for another (in case a device breaks or to add devices), the other devices must also be included in the federation prior to the start of simulation.

  All components of the AFRL/HEA DMT are DIS and HLA network compatible. The DIS is a well-defined and accepted standard. HLA, however, has several problems. First, HLA cannot be done "on the fly" because as previously mentioned, the federation must be predefined. Second, HLA does not fully address the bandwidth problem because devices still receive and transmit many PDUs to devices that are within the federation but not currently of interest to those devices. Third, HLA is apparently not well accepted by personnel at AFRL/HEA. Fourth, HLA does not appear to provide the capability for embedded physics calculations. This results from HLA's being a multicast, best-effort protocol, which may allow transmission errors to corrupt physics calculations. Finally, neither DIS nor HLA addresses standards to handle either latency or security. There appear to be no technical barriers to addressing any of these problems.

- **Target improvements to DMRS visual displays to improve both resolution and depth perception.** The visual system (image generator and visual display) for the AFRL/HEA DMT appears to be state of the art, but it remains inadequate for some *task* training. Simulator visual systems have three technical limitations. The first is display computational speed (the time it takes to calculate and then write the visual display). Computational speed itself was considered in the section above on latencies. Selective fidelity is a method of reducing computational requirements by limiting high resolution either to targets, or to where the pilot is looking. Both of

these approaches result in negative training. A proposed alternative is to use parallel raster scanning (a new technology), which decreases the time to write the display.

The second technical limit in visual display systems is the resolution of the visual display itself. The AFRL/HEA DMT display resolution corresponds to approximately 20/40 vision. This is adequate for *mission* training, but it is less than half the resolution that would be required for high-fidelity *task* training. As a result, for task training, targets must be marked in the visual display with colored lights or be enlarged in order to be seen and their character determined at a realistic distance. For task training, this limitation results in negative training.

The third technical limit in visual displays is depth perception. Depth perception capability in simulation is essentially nonexistent. The panel did not discuss with AFRL/HEA personnel possible technical improvements to depth perception, but such improvements might be possible with a system using stereoscopic vision (3-D glasses) or holographic imagery.

One of the contractors for DMT is proposing the development of laser displays, which will have a smaller spot size (greater resolution) and a broader color spectrum. This could increase the resolution of the DMT display to an equivalent of 20/20 vision or better. The technical feasibility in developing laser displays with this resolution is not clear, but experts believe such systems could be fielded within 3 to 5 years. In the meantime, DMT visual displays are adequate for realizing many of the goals of mission team training.

- **Emphasize realism in the simulation environment and use simulator exercises for behavioral and technical performance evaluation.** For simulators to be used at a higher level than for basic training, they must explicitly include the spectrum of uncertainties that are characteristic of battlefield situations.

  At the conceptual level, a serious challenge is the introduction and representation of credible and effective threats. This requires appropriate representation of opponents' actions. One solution is the "human-in-the-loop" option in which two simulators act against each other. This, however, is not always feasible because, for example, there may be no simulator to represent the opposing system. The threat (including actions and reactions) then has to come from a database within the simulator, and the use of these data should be based on probabilities and the principles of artificial intelligence.

  To be realistic, this database must represent the variability of doctrines and human behaviors. The pilots and commanders have to train against a credible and realistic opponent. In the world of computer games, such opponents are not generally programmed to make mistakes. In a battle situation, pilots must be capable of recognizing mistakes and taking advantage of them. Simulators of specific systems must therefore be designed to represent randomness in their own system performance, in threats and system performance on the other side, and in human behaviors. The latter can be represented by a spectrum of personalities and variations of individual behaviors within each type.

  The rating of officers and pilots trained in such simulators must then reflect their attitude toward risks and uncertainties and whether they display the level of aggressiveness (or prudence) desired by the higher levels of command. A "perfect" adversary (who makes no mistakes) may be the right opponent for basic training, but for more senior pilots and commanders, a "perfect" response may encourage an overly conservative behavior that may not be desirable in real situations.

  Integrated simulators involving several systems, particularly those used in training for OOTCW, must include not only the uncertainties inherent to each system but also those of performances at interfaces of the different components. Those uncertainties in the linkages among the different parts of the U.S. armed forces are critical to the effectiveness of complex operations.

The simulator representation of uncertainties in the behavioral part of these systems can be achieved in practice by algorithms of selection of various alternatives within a database of action-reaction scenarios representing enemy behaviors. The simulation of uncertainties in the technical and operational parts of the system can be achieved through the development of extensive fault-tree and event-tree analyses involving both systems and interfaces.

An important aspect of the analysis of these technical and operational failures is that they are often influenced by human and organizational errors. The modeling of uncertainties in system performance must therefore include not only the probabilities of technical component failures but also the human decisions and actions (for example, maintenance) that often cause these failures and the management decisions that condition these human behaviors. The latter include, for example, constraints of schedule and resources that may provide incentives for shortcuts.

The design of such complex simulators therefore requires (1) meeting the technical challenges involved in the design of the simulator's hardware, (2) the sophistication of a database needed to represent credible threats and all associated uncertainties, and (3) a performance rating system that reflects what commanders want to see on the battlefield.

The treatment of uncertainties is generally one of the weakest parts of military system models. The challenge is not only to perform an appropriate analysis of these uncertainties, for instance, by probabilities based on statistics and expert opinions, but also to represent the results in a way that is helpful for quick decision making.

This problem is not unique to the Air Force. The Army, for instance, faces a similar challenge in the design of the simulators in which it trains commanders of tank units. Human and technical uncertainties are bound to remain a key component of battlefield situations. They are critical to the support of both mission planning and tactical decisions. They are just as critical in the planning of complex OOTCW, which involve a still larger number of components both military and civilian.

The introduction of such uncertainties in DoD models and simulators requires the involvement not only of engineers but also of behavioral scientists and specialists of the different aspects of operations. It also requires the active involvement of top commanders who must eventually decide what level of simulator sophistication is sufficient for effective training and what attitude toward risks and uncertainties should be cultivated in warfighters.

What is needed at this time is appropriate integration, better threat models, and proper representation of randomness and uncertainties in human behaviors and technical performances. Such integrated simulators will be useful in mission planning and rehearsal, as well as in the training of individuals whose simulator performance will be part of a general system of evaluation. The current rating system is based mostly on the knowledge of procedures, and the evaluation is based on cockpit management rather than mission results.

9.4.2 Current Experiments, Training, Exercises, Doctrine, and Education

Recommendation: Integrate OOTCW more completely into ETE doctrine and education. The ad hoc efforts dispersed through the Air Force are to be commended. A more deliberate institutional effort is needed, however, to address OOTCW in balance with MTW preparation, especially in light of the current pervasiveness in the Air Force of OOTCW.

Specifics Associated With the OOTCW Integration Recommendation

A. Expand JEFX to include OOTCW by routinely inserting dedicated OOTCW scenarios in planned experiments. JEFX provides a high-leverage opportunity for developing OOTCW operational concepts and introducing OOTCW-specific technologies. Although planning is complete for JEFX-99, there is time to influence scenario development for JEFX-2000 and beyond. As JEFX becomes even more joint with the addition of the other Services and unified commands, the realism of OOTCW scenarios could be greatly enhanced. The recommended pattern to maximize the experimental opportunity for each EFX is a hybrid approach that has an OOTCW initiating scenario evolving from simple to more complex operations and then further escalating to a conventional military engagement.

B. Develop a clear transitional strategy for experiment findings and recommendations. The transition process for key recommendations from an EFX into an acquired capability or new CONOPS for the Air Force must be developed, understood by all participants, and implemented. The EFX program is already seeing many of its useful results not acted upon because follow-on processes and responsibilities from an experiment remain undefined. The Army has established a Rapid Acquisition Program that accommodates similar findings developed at its battlelabs and gives the appropriate priority for funding and acquisition of important new capabilities properly tempered by independent analysis of the battlelab recommendations. The Air Force had a similar program during Desert Storm called the Rapid Response Process, but it apparently was terminated shortly after the war. The Air Force should consider the resurrection of that process and adapt it for concepts and technologies identified during JEFX to realize the promise and intent of the EFX program.

C. Expand Flag exercises and training for OOTCW. Leverage current warfighting scenarios to include escalating OOTCW dimensions. In parallel with the recommendation above for EFX, existing flag plans should be leveraged to include escalating OOTCW dimensions as normal practice. Although both Red and Blue Flags had OOTCW planned in exercises for the end of fiscal year 1999, there appears to be no process to ensure that this practice continues. Including OOTCW in warfighting exercise offers the parallel advantages of operational practices with the realism of escalating scenarios. In addition, with the advent of DMRS, units could participate "virtually" in the escalating scenario at their home station prior to deployment. They would then be better prepared for the live training performed at Red Flag. With OOTCW missions becoming more pervasive, a greater percentage in both quality and quantity of the Flag exercises should be devoted to OOTCW.

D. Expand Air Force participation in USACOM joint experiments and training with special attention to OOTCW opportunities. As stated above, the Joint Experimentation Program is in its formative phases. This should provide an excellent window of opportunity for the Air Force not only to participate with USACOM but also to influence its areas of focus. The Air Force, through ACC, should make a concerted effort to coordinate closely with USACOM J9 as it continues to develop the Joint Experimentation Program.

E. Evolve Air Force doctrine to include current OOTCW doctrine. Develop plans and approaches for dealing with contingencies intrinsic to OOTCW. As noted above, the draft of a completely rewritten AFDD 2-3 for MOOTW is in coordination. On initial review, the draft appears to do a credible job of reflecting current joint and Air Force views on OOTCW doctrine. The document was ready for the Air Force Chief of Staff signature in the August–September 1999 timeframe. It will provide the basis for further research and doctrinal evolution.

F. Evolve Air Force education programs to include OOTCW. Increase emphasis on OOTCW in all PME curricula and include lessons learned, doctrine, and joint, coalition, and noncombatant issues. An evolving body of knowledge and set of courses to address OOTCW should be further developed. Air University should make OOTCW a special area of emphasis during curriculum reviews and ensure that OOTCW receive adequate coverage throughout the PME system. An excellent basis is

the growing body of lessons learned by operators throughout the Air Force who are spending substantial parts of their deployed duty in OOTCW. Air University should also closely coordinate with the Air Force Doctrine Center and immediately include changes to OOTCW doctrine as soon as it is approved. Air University should also remain aware of operational concepts and technologies that are proved through the JEFX program. Over time, a substantial body of learning will be documented and find its way into curricula integrated in a balanced way with MTW.

9.4.3 Recommendations for ETE From Other Study Panels

Some specific additional recommendations for ETE emerged through the findings of other panels on this study.

Global Intelligence Guide. The Intelligence and Vigilance (I&V) Panel identified the need for the development of a process to create "just-in-time Michelin Guides" for the country or region within which operations are to be conducted. The guide should include standard "tourist" information such as accurate maps, language basics, and cultural norms. In addition, special military information such as the airfield and air traffic control systems, communication infrastructure, and key government and military installation locations, is important to include. Rehearsal tools should augment the guide to prepare anyone interacting with local constituents or the media. USACOM, for example, has a replication of a television newsroom for practicing formal interviews in the "CNN" environment.

Airlift Training and Simulators. The Deployment and Sustainment Panel found that simulators for most of the airlift platforms are substandard for training and should be upgraded both to improve effectiveness during live-fly training opportunities and to give airlift assets a more level playing field in the DMT or DMRS environment. Since airlift plays such a significant role in many OOTCW scenarios, this recommendation should be seriously considered. In addition, the level of airdrop training should be reassessed. Many operators find the current requirements excessive.

Training in the Joint Operational Planning and Execution System (JOPES). The need for personnel who are better trained in the use of integrated planning tools has been called for. The current system is JOPES. JOPES was designed as a deliberate planning tool to automate the manual processes previously involved in developing operations plans. Over time it has been improved in a number of respects. However, processes such as synchronization of databases make it slow, and the lack of higher-level automation and decision support means that users require extensive functional knowledge and expertise in using JOPES tools. In the long term, integration of tools such as the Deliberate and Crisis Action Planning and Execution System, currently under development, into JOPES will improve responsiveness and support to planners. In the near term, MAJCOM staff have an urgent need for more JOPES-qualified personnel to meet current needs, especially in the contingency planning environment typical of OOTCW.

Theater Battle Management Core System (TBMCS) Training. While this study is recommending the termination of any future upgrades to the TBMCS as opposed to a new architectural construct, there is an important interim need to improve the training system for TBMCS. For example, simple, user-oriented cues for computer response to operator commands are needed, as well as more robust controls in the system to prevent the frequent downtime that the very lack of cues tends to stimulate.

Integrated ETE. A general recommendation that also would benefit OOTCW preparedness is to more effectively marry C^2, ISR, and combat elements during Flag exercises to practice force package integration. The OOTCW escalation approach recommended above is but one example of an opportunity to do this. The Air Force must take advantage of every opportunity for integration in the context of the AEF.

An important integrated concept for the Battlelab and EFX experiment domain is to assess the nested TBMCS 2 concept as recommended by the Force Management Panel. TBMCS 2 represents a new C^2

architecture that will need further development before introduction into the operational environment. The success of TBMCS 2 will depend on some level of progress in the Integrated Information Management System (IIMS) proposed by the I&V Panel. The IIMS requires integration of intelligence and surveillance data based on varying phenomenologies and then distribution at the right level to the requesting force element in a timely way—the elements' NTK and timing requirements being orchestrated by the TBMCS 2. IIMS in itself requires considerable experimentation as well as integration into the TBMCS 2.

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Appendix 9A

Experiments, Training, and Exercises Mission Statement

The tasking to the ETE Panel encompassed three main elements:

- Identify ETE issues and needs unique to OOTCW.
  - Assess current and planned U.S. Air Force capabilities to train and maintain readiness for provided OOTCW vignettes
  - Survey current and developmental technologies for opportunities to apply technology to new operational capabilities
  - Postulate evolutionary and revolutionary concepts (materiel and tactics) and technologies for ETE
- Relate these issues and needs to current joint and combined exercises, including EFX and USACOM activities
- Relate these issues and needs with training and exercise initiatives taken since the 1997 Air Force Scientific Advisory Board Summer Study on the AEF

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Appendix 9B
Visits and Contacts

9.B.0 Organizations Contacted

9.B.0.1 Air Force

- Directorate of Command and Control (AF/XOC), Modeling, Simulation, and Analysis (DMT)
- AF/XOOT (Air Force exercises, flying hours)
- AFRL/HEA (DMT concept and demonstration)
- TACCSF (distributed simulation for combat forces and ISR)
- 58 Special Operations Wing (SOW) (mission training and rehearsal)
- ACC, Exercises, Planning, and Employment Division (ACC/DOOE) (Flag exercises)
- ACC, Directorate of Aerospace Operations (simulator requirements)
- ACC, Capabilities Development Division, Distributed Mission Training Branch (ACC/XODZ) (DMT-A)
- ACC, Training and Exercise Division (fighter/bomber flying hours)
- AMC, Directorate of Operations, Aircrew Training, and Resources (tanker/transport flying hours)
- Air Force Operation Test and Evaluation Center—Detachment 1 (AFOTEC/Det1) (rapid testing)
- Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center (AC2ISRC) (C^2 training and simulation)
- ASC/YW (DMT-A operations and integration efforts)
- AFAMS (modeling and simulation)
- Air Education and Training Command (AETC) (Air University curriculum)
- Air Force Doctrine Center, Directorate of Requirements (MOOTW doctrine)

9.B.0.2 Other Services and Joint Efforts

- DARPA What-If Simulations System for Advanced Research and Development (WISSARD) Facility (STOW)
- Joint Advanced Distributed Simulation JTF (distributed test and evaluation simulation)
- USACOM (joint training, doctrine and experimentation)
- Institute for Defense Analysis (IDA)/Joint Advanced Warfighting Program (joint experimentation)
- JCSAR JTF (testing and training)
- Naval Sea Systems Command (Navy combat systems training)
- Naval Surface Warfare Center (BFTT)
- U.S. Army Training and Doctrine Command (OneSAF)

9.B.1 Detailed Summaries of Information Obtained

9.B.1.1 Air Force

AFRL Human Effectiveness Directorate (AFRL/HE), Warfighter Training Research Division, Mesa, AZ, and Director, AFRL Human Effectiveness Directorate, Wright-Patterson AFB, OH

The AFRL/HEA is the Air Force's organization for research and development (R&D) in warfighter training techniques and technologies. Col Jerold Straw (the commander) and Dr. Dee Andrews (the Division Technical Advisor) and their key personnel hosted the panel. The division's mission is to "develop, demonstrate, evaluate and transition training technologies and methods to train warfighters to win." The lab believes that classic individual procedure-based training must be supplemented by full-mission training to adequately prepare warfighters for the challenges of the 21st century. Modeling and simulation are expected to provide on-demand, realistic training opportunities through an integrated operations environment composed of live, virtual, and constructive training capabilities. The lab has three focus technology areas: (1) warfighter training effectiveness behavioral research, (2) DMT technology engineering development, and (3) night vision device aircrew training R&D. The lab has a command, control, and communications simulation, training, and research system (C^3STARS) facility, which offers the opportunity to investigate complex decision making among interdependent team members within a dynamic and realistic setting. Crewstations and scenarios simulate the air defense mission of an AWACS platform. The C^3STARS enables the collection of individual and team performance metrics based on data capture of the team members' behavior, in addition to the subjective ratings of individual or team performance. This facility enables the representation of a wide variety of weapon systems and training scenarios, including Rivet Joint, JointSTARS, AWACS, unmanned air vehicles, and satellite tracking and surveillance systems. With dramatic improvements in high-speed datalinks and computational capabilities, the C^3STARS facility can support air, space, and information warfighter training while making that training affordable and realistic. The capability of the facility is enhanced by connecting the crew stations to the ADS network, enabling assets at other DoD facilities to be integrated into multiforce simulation exercises. Performance metrics are generated to provide operationally valid indices of individual and team performance within a mission scenario. Metrics span the different levels of analysis from individual performance to more team-level processes and outcomes such as team communication effectiveness and DMT effectiveness.

The AFRL/HEA also provides embedded and off-equipment technologies to permit near–real time assessments of decision outcomes and the "value added" return-on-investment of technology for total force training, mission rehearsal, and mission performance. Their efforts are relevant to enhanced individual performance, team performance, and mission performance.

The space warfighter community has identified critical areas where AFRL is helping: Almost all current space training of operators takes place in over-the-shoulder mode. There are no simulators for most training and not much in the way of computer-based instruction. Also, there is no capability to conduct all-asset mission planning and rehearsal. Ground-based simulation training is rapidly expanding to include highly complex and realistic combat scenarios. Visual simulation technologies are critical in creating realistic scenarios. Advances in visual simulation technology continue to be made in image generation, display, and database systems. However, many of these advances have not been tested in an operational environment.

Discussions were also held with personnel at Headquarters (HQ) AFRL/HE: James Brinkley, director of the Human Effectiveness Directorate; Richard Warren, science associate to the AFRL/HE chief scientist; and Gilbert Kuperman, information warfare (IW) specialist, Crew System Interface Division. The Human Effectiveness (HE) Directorate is concerned about the future of human effectiveness technology and research. Recently there have been cuts in the "softer" human projects in favor of "hardware" technology

programs. For example, efforts in selection and training of personnel are being phased out, and the imbedded information training and space areas at Brooks AFB are being hit hard. They are downsizing from 50 psychologists to 2. They are very supportive of the work at Mesa and feel that the "feasibility" of the concept of DMT has been demonstrated but that it was an "experiment" and will require much more work before they have operational confidence. The areas for improvement are visual displays and MLS access. OOTCW are recognized as important, but have not been integrated into the HE work to date. Regarding the AEF concept, an IW specialist's opinion was that AEF training and exercises are lagging and that the Air Force is 3 years behind the Army and Navy in preparing for such efforts. A recommendation was made to have the Air Force Studies and Analyses Agency study the AEF and validate the model so that acquisition budgetary decisions and trades can be made. In our current Cold War model, it takes years to collect intelligence data. In today's AEF environment, we may have only days or hours. The need for intelligence and information superiority is more pronounced for OOTCW than during the Cold War. It was recommended that the Air Force evaluate the attributes of each type of OOTCW and list the differences, for example, in OPTEMPO or assets deployed. Retraining is a major issue and could take 6 months to retrain people to effectively and efficiently transition from one operation type to another.

Additional training to deal with cultural biases and communications in foreign languages may be required. The political ramifications and military consequences of errors or accidents (for example, loss of a transport plane) in OOTCW may be more severe than in conventional warfare. Also, Congressional support for these mission types is a very important factor for acceptance by military individuals. "Will DoD and the Air Force recognize OOTCW as legitimate operations and fund them?" OOTCW are now viewed as "other duties as assigned," not as primary missions, yet OOTCW have consumed considerable resources and influenced morale for many years.

Theater Air Command and Control Simulation Facility, Kirtland AFB, NM

TACCSF is a unique facility with high-fidelity warfighters in the loop with a tactical C^2 and weapon system simulation. The panel interacted with the personnel and received a tour of the TACCSF testbed and its linked weapon system simulators. TACCSF personnel were enthusiastic about their capabilities and their vision for becoming the "Air Force's Human-in-the-Loop Simulation Center of Excellence." TACCSF has experience successfully operating as the ADS leader in six events with more than 30 sites participating (Roadrunner-98, Coyote-98, and Joint Theater Missile Defense Attack Operations, Blue Flags, and EFX). Sensors involved were Cobra Ball, Rivet Joint, JointSTARS, modular control equipment, and AWACS. TACCSF has worked with Army, Navy, and Air Force assets and built the first F-15C (four-ship) simulation with the Joint Tactical Information Distribution System. It has designed, built, and maintained a certified airborne laser ADS simulation. The JCSAR CONOPS was based on TACCSF simulations. TACCSF has demonstrated mission rehearsal capabilities across the joint spectrum. In April 2000 the TACCSF will move into a newly constructed facility with simulators for TBMCS, Global C^2 System, Rivet Joint, F-15E, generic fighter, missile tracker, Virtual Red Integrated Air Defense System, unmanned aerial vehicle/multiple user shared environment, portable space model, and unattended measures and signals intelligence sensors. TACCSF has upgraded its capability for AWACS, modular control equipment, the tactical Information Broadcast System, and Patriot systems. Its virtual interactive environment worldspace includes DIS and HLA and local area network communication links with domain options for air, land, surface, subsurface, and space. The TACCSF reports to the Command and Control Training and Innovation Center of the Aerospace Command and Control ISR Center (AC2ISR) at Langley AFB, which jointly reports to the Commander, ACC (COMACC). TACCSF has a mix of 35 Air Force and Government civilians and 79 contractors with experience and capabilities in fighters; AWACS; intelligence; engineering; analysis acquisition; software; verification, validation, and accreditation; modeling; testing; and support backgrounds.

58th SOW and AETC Training Support Squadron, Kirtland AFB, NM

Col John Folkerts and Lt Col Dan Briand gave the panel an in-depth look at the training and simulation facilities at the 58th SOW and the AETC Training Support Squadron, including presentations on the Consolidated Learning Center, the training observation center, and mission planning capabilities. In addition, panel members received hands-on experience in the simulator aircraft platforms (H-60, Talon II, UH-1, HC-130, and HJ-53). The 58th SOW's mission is to train advanced helicopter and HC-130 aircrew students. The unit also provides people and airlift needed in response to crises around the world and assists civilian authorities in regional rescues. Since moving to Kirtland, the wing has flown more than 205 rescue missions and saved more than 200 lives. These missions feed back to help train the students, who, after they finish their courses, go on to fly with Air Force Special Operations Command, AMC, ACC, Pacific Air Forces, USAFE, Air Force Space Command, and Air Reserve Components. The curriculum includes classroom and computer-aided instruction, simulator training, and flying. The flying includes transition and instruments, aerial refueling, personnel and equipment airdrops, and helicopter hoist training and combat tactics, including flying with night vision goggles.

HQ ACC/XODZ, Langley AFB, VA

DMT within the Air Force was initiated through the efforts of Gen Richard Hawley, COMACC. Gen Hawley understood the difficulties involved in being able to "pull all elements of our warfighting team together to train … at the same time in peacetime … [it's] almost impossible ... rarely happens." His vision (about 2 years ago) was to remedy those difficulties with Distributed Mission Trainers, which would be able to "provide our aircrews [with] … combat training to include mission rehearsal every day of the week, fifty-two weeks a year … an unprecedented improvement in the quality of training that we provide to those troops that we ask to go execute our mission every day."

This direction to the ACC staff has evolved into DMT-A. DMT-A proposes to provide aircrews with enhanced training in a synthetic battlespace. DMT-A is designed to train aircrews in a realistic, fully integrated environment, capable of supporting the entire spectrum of training from individual training to campaign-level mission rehearsal. The program is being funded from operations and maintenance accounts and has a 10-year development horizon to reach full mission-rehearsal capability. It is beginning with training devices and a Distributed Warfighting Center (DWC) at a location to be determined. It will expand incrementally to include a majority of ACC weapon systems.

The ACC concept envisions a two-phased approach. Initially, ACC will concentrate on team training within a squadron or wing. It will then progress to a mission-rehearsal phase using true distributed training among and between forces at separate bases. The team-training phase consists of training in three skill categories. These are (1) individual skills (dynamic skills and individual tasks needed to effectively employ a weapon system as part of a team); (2) team skills (flight and element skills needed to execute missions or significant portions of missions—for example, air combat maneuvering); and (3) interteam skills (collective skills needed to execute missions—for example, F-15C flights and AWACS conducting defensive counterair). The mission-rehearsal phase will be based on mission-essential tasks derived from real-world missions and should replicate mission battlespace conditions (terrain, weather, imagery, and opposition forces). This phase should also produce the capability to perform real-world mission previews.

ACC has acknowledged that DMT will play a very important role in the training of AEFs in the EAF concept. Because the forces in a particular AEF are not normally co-located, the ability to train together in the DMT environment for a particular deployment option or real-world contingency in the mission-rehearsal phase described above will play a major role in the ability of a particular AEF to stand alert or deploy.

As stated above, the initial capability has been installed with a “four-ship” of F-15C trainers at Eglin AFB, FL. This became operational in May 1999. The second F-15C “four-ship” is in the final stages of installation at Langley AFB, VA. (These “F-15C Mission Training Centers” are turnkey operations provided by a contractor on a fee-for-service basis. They do not belong to the Government and there is no plan for the Government to purchase these training devices.) These trainers, along with the AWACS device at Tinker AFB and the DWC, represent the first incremental phase for the ACC DMT roadmap. After these become operational, a training effectiveness evaluation was performed from July through September 1999 with a briefing to COMACC to follow in December 1999.

ACC has a request for proposals outstanding for the next set of trainers for the F-16, to be fielded under the same turnkey concept in the 2001 timeframe. This will be followed in turn by other ACC weapon systems as system maturity and funding allow. Figure 9-3 describes the ACC DMT roadmap. As shown, the roadmap is truly an evolutionary approach. Although it will reach ACC’s goal of a “robust mission environment” by 2006, it will not reach “campaign-level mission rehearsal” until the 2008 to 2010 timeframe. ACC also envisions an ancillary capability to provide a synthetic battlespace for important non-operational capabilities, that is, experimentation and exercises.

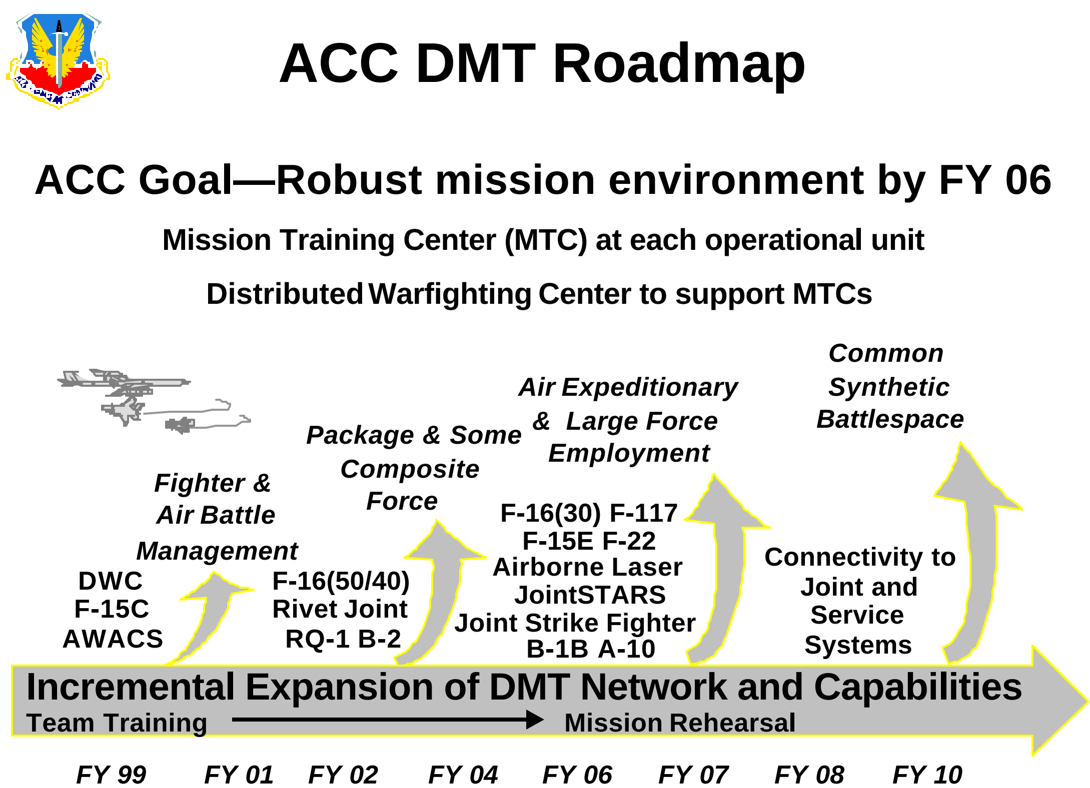

Figure 9-3. *ACC Distributed Mission Training Roadmap*

ACC’s DMT-A is a component of the Air Force DMT. (In fact, the reason ACC named it DMT-A was to distinguish it from Air Force DMT.) The Air Force has established a DMT IPT to work DMT issues. It is co-chaired by representatives from both the Air Staff (XOC) and ACC/DOT. The purpose of the DMT IPT is to (1) formulate and manage an integrated, multicommand strategy to achieve a fully interoperable, Air Force–wide training system; (2) set priorities for integrating core capabilities, ensuring interoperability, and eliminating redundancy; and (3) provide synchronization, oversight, and direction for the development of the DMT Air Force–wide system of systems. The Air Force DMT vision is to

provide a distributed mission capability in which all DMT training will come under the auspices of Air Force DMT.

The panel also had a telephone conversation with Larry Krussel, the OPR for the ACC Final Capstone Requirements Document for DMT. The document was signed by Gen Richard Hawley, COMACC, on 23 October 1998. It describes the Air Force's requirement for a training and mission-rehearsal system needed to achieve and maintain individual, team, and composite force skills for air and space crews and system operators. The goal is to give crews the capability to train as a complete combat team in a virtual battlespace. DMT will link high-fidelity simulators of aerospace C^2ISR systems into a shared interactive network. Operational and support systems will be capable of integration with DMT when appropriate. Eventually the DMT environment will include constructive, virtual, and live entities to allow individual aerospace crews and system operators to experience and train alone or in conjunction with friendly forces and against the threats they would face during actual operations. DMT operations and integration will include Air Force–wide management of training operations and network architecture. Responsibilities include establishing standards for interoperability of database and network elements to meet training requirements. Operating the DMT network includes scheduling, maintaining federation databases, managing scenarios, validating network participants, and evaluating system problems.

HQ ACC, Director of Air and Space Operations (ACC/DO)

MGen David MacGhee, Jr., ACC/DO, discussed his philosophy on the role of simulation-based aircrew training to build individual, team, and interteam skills and the necessity for the training to be delivered to the aircrew to augment current live training. MGen MacGhee views simulation as an important part of current aircrew training and as providing an adequate environment for developing individual aircrew skills such as instrument and emergency procedures. However, the fidelity and independent nature of the current aircraft simulators prevent them from providing an environment to develop team and interteam skills. With increased demands on personnel and equipment, more deployments, and limited budgets, the team and interteam training opportunities are becoming more limited. These limitations, coupled with geographically separated AEF units, point to an obvious need for a system of networked, high-fidelity, distributed simulators that can provide an environment not only for individual skill development, but also for team and interteam skill development. Although the technology appears to be capable of delivering this capability, MGen MacGhee cautioned that in the past, the simulation technologies could not live up to their promises. MGen MacGhee views ACC's current acquisition strategy as the most prudent approach, first purchasing a few linked four-ship F-16 and F-15 simulators, then networking those simulators after the technology has been proven, and finally adding all other combat elements to the network.

HQ ACC/DOOE

Mr. Gary Sambuchi discussed the impetus behind Flag exercises, the current focus, and future initiatives. Lessons learned from previous conflicts, especially Korea and Vietnam, indicated that aircrews had no experience against postulated enemy tactics and that survivability rates grew significantly after the first 10 missions. To provide aircrews with the needed experience, an Aggressor Squadron was created in 1972 and trained in the tactics of the enemy. This Aggressor Squadron then traveled to and flew against operational squadron aircrews to give them experience against a likely enemy. In 1975, the Nellis AFB range complex was expanded to provide a more robust environment where crew members could fly against the Aggressors while adding realistic target arrays and integrated air defense systems; this was the beginning of Red Flag exercises. Today, the Nellis Range Complex includes 3.1 million acres with 1,400 bombable targets and 50 manned threats to support five Flag exercises a year for all U.S. Services and 23 foreign countries. One of the more important aspects of the Nellis complex is the instrumentation that can record and replay missions to provide a robust debriefing capability. Flag exercises not only give aircrew members "the first 10 missions" but also the opportunity to develop team and interteam skills with joint

or combined assets in a robust environment. The primary focus of Flag exercise missions is MTW operations. Recently, however, some effort has been made to include MOOTW. In the future, in addition to the aforementioned opportunities, Flag exercises should include more OOTCW scenarios and tailor exercise schedules to fit within the AEF cycle.

The Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center

Lt Col Dave Clarke discussed the Theater Air Control System (TACS), which is the primary means by which the JFACC plans and executes the air battle. The TACS centrally plans the air battle at the air operations center (AOC) level and executes the air battle by using a variety of TACS elements, both airborne and ground-based. The TACS is flexible and can function across the spectrum of operations from MOOTW through MTW. TACS flexibility will be significantly enhanced once the Operations Support Center, AOC, and Battle Control Center and Radar Communications Cell are fully developed and fielded (about 2005). The TACS is a compilation of many elements tasked to come together and act as one system. While current training for individual weapon systems and team functions is effective, realistic training for the entire C^2 system presents a challenge.

The TACS supports the joint forces commander in conducting theater battle management operations and includes a single integrated air picture, surveillance, ATO-air control order execution, time-critical targeting, close air support, search and rescue, integration with AWACS-JointSTARS, Aegis–E-2, Joint–Host Nation Sensor Integration and Patriot execution. The AOC is the JFACC's theater battle management organization for planning and prosecuting the air battle.

The TACS is the JFACC's C^2 planning and execution tool for all air activities within its area of responsibility (AOR); it plans and executes immediate requests for close air support, ensures that rules of engagement (ROE) are adhered to, and develops real-time and near–real time integrated air pictures and distributes air pictures to worldwide customers. For the operations in Kosovo, the TACS was fully deployed through the AOR and worked for the combined AOC in Vicenza, Italy. Air Force assets are fully integrated with host nation, NATO, and U.S. Navy C^2 platforms. In Southwest Asia, TACS operations include only one ground element combined with airborne platforms. Using tactical digital links, an air picture is developed and forwarded to a host nation AOC-type element. Because the TACS has become a high-demand, low-density force element, all active-duty elements of the Ground TACS are fully deployed, and supporting Air National Guard Control and Reporting Center/Control and Reporting Element squadrons have been activated and are in place supporting Operation Allied Force.

ATO execution includes offensive counter-air, defensive counter-air, combat search and rescue (CSAR), high-value asset protection, and air refueling. Surveillance and ID include conducting radar and sensor surveillance for the entire theater, identifying all airborne objects, ensuring that all gaps in radar coverage are filled, implementing the Air Control Order, and serving as a real-time intelligence-collection node. Using near-term available technology, the modernized Ground TACS system will centralize all major battle management functions in the battle control center, with only the radar sensor and communications radios being sent forward.

TACS team training includes individual skills, team skills, and interteam skills. The TACS has a DMT C^2 network managed by the TACCSF (see the previous description of TACCSF) with the objective of allowing extensive scenarios and more team training opportunities than previously provided.

The Air Force Agency for Modeling and Simulation—Program Support Division Chief

Dr. Connie Fischer, who briefed panel members, has oversight of all simulation programs to support the AFAMS mission to "implement Air Force, Joint and DoD modeling and simulation policies and standards, and provide modeling and simulation support to Air Force, Joint and combined activities." Additionally, AFAMS provides an interface between HQ Air Force and the AC2ISRC's Command and

Control Training and Innovation Group, USAFE's Warrior Preparation Center, USACOM's Joint Training, Analysis, and Simulation Center, the Pacific Air Forces' Korean Air Simulation Center, and the Air Force Materiel Command's Electronic Systems Center.

AFOTEC/Det1, Kirtland AFB, NM

AFOTEC/Det1 provides rapid test and assessment for traditional and nontraditional test and evaluation. The detachment is a leader in applying off-the-shelf, state-of-the-market technologies to solve customer requirements. The detachment has supported Air Force battlelab initiatives, ACTDs, and the joint warfighter. The Detachment has the infrastructure to support simulated and "real" exercises or tests, and it works for customers on a "pay as you go" basis. It can perform a short project lasting a few days or a longer one. Its capabilities can augment the infusion of commercial off-the-shelf or near-term technology into Air Force operations.

HQ USAF/XOOT, the Pentagon, Washington, DC

Lt Col Bob Medvetz, HQ USAF/XOOT, presented a briefing to provide an understanding of Air Force exercises. Joint Publication 1-02 defines an exercise as "a military maneuver or simulated wartime operation involving planning, preparation, and execution. It is carried out for the purpose of training and evaluation. It may be a combined, joint, or single-Service exercise, depending on participating organizations." Preparation for an exercise begins with defining the requirements and establishing a schedule. The purpose and audience of the exercise are the major factors. A master schedule is established, with the average planning time for an exercise being 18 months. Several concept development conferences are held in which the exercise objectives, exercise directives, and training plans are developed. After the exercise, an after-action report is completed in about 120 days.

Exercises types include

- Field training exercises—conducted in the field under simulated operational conditions
- Command post exercises—designed to practice or demonstrate C^2 capabilities with exercise combat forces normally simulated
- CAXs—using modeling and simulation to assist the exercise. (CAXs can link with command, control, communications, computers, and intelligence (C^4I) systems without employing large numbers of supporting personnel.)

There are two types of exercises that the Air Force participates in: (1) JCS exercises, which are CINC-sponsored and designed to that particular CINC's training objectives, and (2) Air Force exercises designed to fulfill Title 10 training requirements (organize, train, and equip). These exercises are normally sponsored by a MAJCOM. Air Force participation can be further broken down into two categories: (1) deployment and redeployment support to the exercise participant, that is, the airlift support associated with getting the participants to and from the exercise location; and (2) the air component, which includes active participation of forces in the exercise.

Examples of JCS exercises are Roving Sands, a Joint Tactical Air Operations exercise employing Army air defense artillery and Air Force, Marine Corps, Navy, and allied air assets; and Unified Endeavor, a computer-aided exercise designed to train the CINC, Joint Task Force commanders, and their staff.

Examples of Air Force exercises are Red Flag, an exercise designed to fuse existing combat air resources under a central manager to provide continuous combat training for combat aircrews in a realistic environment; Cope Thunder, a Red Flag–type exercise held in Alaska; and Blue Flag, an exercise designed to train combat leaders and their support staffs in command, control, communications and intelligence procedures to run an AOC.

There are two important exercise categories. The first is training, which is the focus of the exercise definition mentioned earlier. Training reinforces what people have learned and allows them to practice it in an operational environment. Since most units replace a third of their personnel every year, training exercises may be the only place where certain team and interteam skills can be practiced. The target audience is the unit personnel learning their primary duty. Blue Flag is a specific example. There are normally three Blue Flags scheduled each year, and the focus is to train a numbered Air Force's AOC. ACC's three numbered Air Forces (8, 9, and 12) are each allocated one Blue Flag to train their personnel. If one exercise is canceled, then that numbered Air Force loses its primary AOC training for that year.

The second exercise category is experimentation. Experimentation in an exercise introduces something different from the norm. This might be the use of new technology (equipment or software), evaluation of doctrine (new or changed), and evaluation of tactics (new or changed). Execution requires personnel familiar with the norm in order to evaluate what is being experimented with, but does not provide a substitute for training exercises where the norm is the standard. Experimentation is used to evaluate and potentially redefine the norm.

HQ Air Force Staff, Modeling, Simulation, and Analysis Division—the Pentagon, Washington, DC

The seed for DMT was planted in 1996 when Gen Fogleman asked AF/XO to lead an effort to meet future training needs by exploiting modeling and simulation advances. Since the effort was started in 1996, it has matured, and Air Force leadership has endorsed the DMT concept as a complement to live flying. However, the Air Force is still seeking the funding investment for an Air Force–wide training and preparation DMT system. The challenge to revolutionize training is driven by the need to overcome current training constraints that include few joint training opportunities, dwindling exercise funds, flying time issues, classified capabilities, safety, high personnel tempo (PERSTEMPO) or OPTEMPO, airspace availability, restricted weapons and electronic warfare envelopes, environmental concerns, and complex ROE such as found in OOTCW. A high-fidelity virtual battlespace with full sensor and C^2 representation and sensor-shooter interactions capable of composite force operations, joint interoperability, and mission rehearsal could ameliorate or overcome many of these constraints.

In October 1997 a decision brief to the Air Force Requirements Oversight Council resulted in the formation of a multi-MAJCOM and Air Staff DMT IPT, the initiation of an Air Force Capstone Requirements Document, and the inclusion of Air Force–wide common core DMT requirements in the program objective memorandum (POM). The DMT IPT is responsible for an Air Force DMT roadmap and POM submissions for total core capabilities.

The DMT concept will support the AEF preparation and deployment cycle and in fact can fill in the holes in live flying. DMT will be able to support individual aircraft and flight training, sophisticated flight package training, and an AEF package practice including C^2. The DMT concept should permit full AEF mission readiness training and provide effects-based preparation incorporating live, virtual, and constructive entities. The environment would support geospecific terrain, ISR-validated threats, strategic and cascading effects, fully correlated representations, and weather effects.

DMT integration and training events to date include Roadrunner 98, which examined technical training requirements and validated the research approach with real warfighters. Coyote 98 exercised emerging technologies to be leveraged for DMT and examined interoperability and constructive environments.

The Air Force Experimentation Office

The panel received a briefing from Col Terry Thompson on AFEO's plans for upcoming experiments. The AFEO stood up on 1 January 1999 and evolved from the EFX Task Force. The AFEO scope of responsibility includes

- Coordinating experimentation activities across the Air Force battlelabs and centers
- Providing oversight of the Air Force experimentation process
- Developing and coordinating the Air Force 5-year experimentation campaign plan
- Conducting the Air Force annual large-scale JEFX
- Representing Air Force interests in all joint-Service experimentation concepts, activities, and planning

Through concept-based experimentation, the AFEO examines innovative warfighting concepts, processes and technologies. Large-scale experiments like JEFX are not experiments in the classical, scientific, or statistical sense, as they are too complex with multiple dependent variables. Instead, experiment hypotheses are addressed in a more qualitative manner against carefully considered specific measures of effectiveness. The experiments are not demonstrations, and as such, failure is acceptable since they still provide learning opportunities.

The first large-scale experiment was EFX 98. It was a year-long effort that included three "mini" experiments and concluded with a 2-week wargame; the experiment included live and simulated flying operations and military actions. The context of the experiment was a rapid deployment and employment scenario representative of a short-notice, large-scale combined-arms attack on a friendly allied nation. The experiment was designed to evaluate the use of advanced C^2 for planning and control of forces while operating in a distributed joint AOC configuration. EFX 98 was considered a success and was the proof of concept about the value of experimentation in helping to implement the EAF vision.

JEFX 99 was in August 1999 and took the lessons learned from EFX 98 and further refined distributed operations. It examined ways to mature C^2 procedures down to the operational level and used two AEFs as the basis of the experiment. It included joint and coalition force participation and more fully integrated space-based and space-derived information for the warfighter. The challenge was to train and tailor the AEF packages needed to counter threats, transport it to the AOR, and provide it with accurate and timely intelligence.

Planning for JEFX 2000 is already under way and the primary themes will include advanced C^2 concepts and technologies and integration of agile combat support considerations; JEFX 2000 execution is scheduled for September 2000.

United States Air Forces in Europe, Ramstein AFB, Germany

The panel had a video teleconference with Col Scott Gray, USAFE, Assistant Director of Air and Space Operations, and key members of the USAFE Directorate of Operations staff. The discussions centered on USAFE's experiences in training for and conducting OOTCW. In 1996, USAFE assigned responsibilities for most MOOTW to 3 Air Force. USAFE had just deactivated 17 Air Force and assigned its former forces to 3 Air Force in England and 16 Air Force in Italy. Since 16 was actively engaged in Bosnia and Turkey, 3 was given responsibility for operations in sub-Saharan Africa. Most of the activity there was involved with Humanitarian Relief Operations and non-emergency evacuations. The discussion focused on USAFE's experience with those operations, planned exercises, task-related training, and USAFE perceptions on what technologies could enhance those operations.

USAFE has had and continues to have an aggressive exercise program in OOTCW. It conducts twice-yearly Field Medical Relief exercises in Africa, which focus on medical readiness, training, logistics, and actual medical care in the countries visited. These exercises, although limited in scope, have been very successful—not only in training medical personnel but in establishing in-country relationships. Late this year or early next year USAFE will expand this concept in an exercise in Cameroon. The exercise will stand up a JTF, with the scenario moving from medical care to simulated humanitarian relief, culminating in simulated evacuation. In the future, USAFE hopes to expand this exercise series to possibly include U.S. Army involvement in securing and protecting an airfield. The USAFE staff believes that this sort of exercise gives very good training to their people and, when coupled with other exercises (NATO's Partnership for Peace and bilateral exercises), keeps USAFE personnel trained for OOTCW. USAFE also still exclusively uses 3 Air Force to command and staff these operations. (The 3 Air Force commander was commander of Operation Shining Hope, the operations in Tirana, Albania.)

With regard to technology enhancements, the staff discussed four broad categories: communications, logistics movement with associated in-transit visibility (ITV), air traffic control (ATC), and state-of-the-art bare-base support equipment (tents, messing facilities, etc.). With regard to communications, the staff stated the need for lighter and more capable initial communications. They had Iridium telephones for their initial entry into Albania for Shining Hope, and stated that the phones were not usable. Their fix was to purchase commercial INMARSATs for both voice and data traffic. Ideally, they would like a system light enough to go in with the first elements for any operation and to support the JTF commander and staff. This would be followed by a more robust communication package requiring C-130 or C-141 lift. The staff's logistics needs centered on the need for better ITV. They understand that there is work going on in this area but would like it accelerated. They also stated that they could use a modeling capability for logistics movements that would predict shortfalls and identify problems before the movements start. ATC was a concern, especially on Third World airfields without radar and approach aids. The staff was pleased with the recent developments in mobile microwave landing systems, but were not satisfied with the lift required to install surveillance radar equipment. (It currently requires five C-5 equivalent loads to transport a full surveillance radar capability.) Finally, lessons learned in Albania, where they used Harvest Falcon and Eagle equipment to establish refugee camps, pointed out the need for light and lean bare-base equipment. The staff indicated that such equipment existed on the commercial market, but neither the Air Force nor the Army had procured any of it.

In sum, they believed they had developed a capable and efficient system to deal with OOTCW, and had both real-world experience and a good exercise base to maintain that capability. They did identify shortcomings in the areas listed above, and solving these problems would add significantly to their capability.

9.B.1.2 Other Services and Joint Efforts

U.S. Army Training and Doctrine Command

OneSAF is an Army program designed to produce a composable next-generation force that can represent a full range of operations, systems, and control processes from the entity level up to the battalion level, with a variable level of fidelity that supports all modeling and simulation domain (advanced concepts of analysis and training, exercises, and military operations) applications with an emphasis on human-in-the-loop and no human in-the-loop. It will replace current legacy SAF systems that have major shortcomings in interoperability, HLA compliance, architecture, major code work modifications, and user friendliness. OneSAF has been in development since 1995 and is scheduled to be operational in 2004 or 2005. OneSAF will be a leading development tool for battalion and brigade commanders and a battalion-level staff trainer. It will be accessible and user friendly and will enable leaders to develop and maintain digital and tactical maturity, operate at higher OPTEMPO, and become "virtual veterans." OneSAF will provide a framework and supporting technology that permit OneSAF components to be selected, configured, and

integrated into a common synthetic environment. OneSAF is becoming the basis for extensions to Navy, Marine Corps, and joint synthetic battlespace environments.

WISSARD Facility, Naval Air Station (NAS) Oceana, Virginia Beach, VA

In support of the DARPA STOW ACTD, the Navy's WISSARD facility, NAS Oceana, Virginia Beach, VA, significantly grew from fewer than 10 computer systems to more than 80. The lab is developing and testing intelligent autonomous entities that populate an integrated synthetic battlespace. Included are simulation execution environments, automated wing operations centers, and graphical user interfaces. A training simulation called TacAir-Soar is employed to model intelligent behavior at the entity level in the tactical air domain. It is fully autonomous and requires a small number of human operators, allowing large-scale simulations without adding expensive human controllers. TacAir-Soar provides behaviors such as air-to-air, air-to-ground, reconnaissance, and refueling operations. It can provide friendly, opponent, or neutral forces. An HLA-compliant ordnance server is under development in support of STOW.

Naval Sea Systems Command, Combat Systems Training Office

CDR Peggy A. Feldmann is the architect of the ASSAULTT ACTD. Given the lack of a DoD capability, the ASSAULTT ACTD attempts to provide a comprehensive capability for joint unit-level, objective-based training while allowing CINCs and subordinate commands to quantitatively measure the results. To help quantify training, the ASSAULTT ACTD will provide each Service with a common architecture for built-in training aids, metrics, and debriefing tools. Service interoperability will be achieved by unifying the synthetic battlespaces used to drive virtual trainers. An added benefit of the ASSAULTT ACTD is a joint mission-rehearsal capability that can allow for "just in time" training.

The ASSAULTT ACTD should achieve its objectives by leveraging and combining the following technology development efforts:

- Objective-based training technologies—the Army's Training Exercise Development System and the Navy's Afloat Training, Exercise, and Management system link joint and Service-specific task lists to performance and effectiveness measurements, providing a comprehensive debriefing capability.
- Synthetic battlespace technologies—the STOW ACTD, developed by DARPA, provides the basis for the continued development of several Service-specific modeling and simulation programs. These programs include the Army's OneSAF, the Marine Corps' Marine Air-Ground Task Force Federation Objective Model, and the Navy's BFTT system.
- Advanced embedded training technologies—an ACTD that provides instant automated assessment and contest-based feedback of an individual operator's performance, as well as team performance.

The ASSAULTT ACTD is organized into three phases: (1) demonstration of the basic capability of all the previously listed technologies to interface with one another on a common testbed, (2) demonstration of the ability to support team aircrew training in a joint or coalition environment, and (3) evaluation of hardware and software developed and installed after Phase 2.

Naval Surface Warfare Center, Dam Neck, VA

BFTT is an in-port shipboard combat training system designed around the concept that the ship is the most effective training site for appropriate operational and functional training. It allows a ship's crew to train using their own equipment, system configurations, and procedures. It provides (1) realistic unit-level team training in all warfare areas, (2) a means to link ships in different homeports for coordinated training using DIS protocols, (3) stimulation to shipboard sensors via onboard trainers provided by

tactical equipment program managers, and (4) simulation of nonshipboard forces such as friendly, neutral, and enemy aircraft and submarines. BFTT uses a STOW environment that interacts with the "learners" (the ship's company being trained). The facilitators for BFTT are a specialized combat system training team who provide combat system events and cognitive debriefing information. The program began in 1991, an ORD was produced in 1992, and initial operational capability was reached in 1997. BFTT will eventually be installed on 158 ships. BFTT and Navy combat systems training are evolving together, and most future Navy combat systems elements will be driven by BFTT. Although BFTT is envisioned to be used in homeport only during interdeployment training cycles, the Navy is exploring its future use at sea.

U.S. Atlantic Command Joint Training Program

USACOM was named the Joint Force integrator and given a new responsibility to design, prepare, conduct, and assess joint warfighting experiments. In October 1998, the CINC, USACOM, was given responsibility for the Joint Warfighting Center, Joint Command and Control Warfare Center, Joint Battle Center, and Joint Warfighting Analysis Center from the Chairman, Joint Chiefs of Staff (CJCS) control. The purpose of the USACOM Joint Training Program is to support joint and multinational training and exercises focused on commanders, staffs, and component forces to assist the CJCS, CINCs, and Service Chiefs in their preparation for joint and combined operations, and to facilitate the conceptualization, development and assessment of joint doctrine. USACOM J-7, with the Joint Training, Analysis, and Simulation Center and the Joint Warfighting Center as its major subordinate units, administers the program. The program fulfills a dual requirement of preserving and advancing joint operational warfighting skills and supporting CINCs' requirements for small-scale contingency operations. The program provides Joint Training System Support Teams, Joint Exercise Teams, and Mobile Training Teams. These teams, along with schoolhouse training, deployable and distributed models, and virtual training support, provide worldwide joint training in 6 categories. These range from U.S. Service component training through joint training up to interagency or intergovernmental training. Modeling and simulation are becoming key to USACOM's training efforts. The Joint Simulation System (JSIMS) is designed to provide a synthetic environment that is live, virtual, and constructive. Coupled with Service-specific models (Air Warfare Simulation, Tactical Simulation, Corps Battle Simulation, etc.), JSIMS will provide a joint theater-level simulation capability. Through these efforts, USACOM provides (1) joint or combined training tailored to requirements, (2) subject matter experts teamed with the training audience and state-of-the-art facilities, and (3) joint training while saving OPTEMPO and PERSTEMPO.

U.S. Atlantic Command Joint Experimentation Program

Joint force integration—the synergistic blending of technology, systems, and doctrine from the different military Services to enhance joint capabilities—is critical to improving U.S. military warfighting capabilities. As an important parallel to its Joint Training and Doctrine Program, USACOM recently established the Joint Experimentation Program. The best way to achieve integration is to develop new systems "joint" from the ground up; experimentation plays a key role in that process. Joint Experimentation is an iterative process of collecting, developing, and exploring concepts to identify and recommend the better value-added solutions for changes to doctrine, organization, training and education, material, leadership, and people required to achieve significant advances in future joint operational capabilities. Joint Experimentation is intended to identify and assess those interdependent areas of joint warfare that will leverage Service capabilities to transform the conduct of future U.S. armed forces operations. Since Joint Experimentation supports *JV2010* and the revolution in military affairs, *JV2010* and future CJCS vision and concept documents will guide Joint Experimentation.

USACOM's role as executive agent for experimentation is critical to the identification, assessment, and integration of those desired operational capabilities necessary to maintain our current qualitative superiority, to achieve the joint force cohesion envisioned in *JV2010*, and to shape the context for the Joint Force After Next. In this capacity, USACOM works closely with the Joint Staff, the Joint

Requirements Oversight Council, the Services, and other CINCs to identify and refine required operational capabilities and doctrinal issues impacting joint operations.

USACOM has already been successful in integrating warfighter concerns into Service budget programs through the Joint Warfighting Capabilities Assessments and Joint Requirements Oversight Council process and CINC Integrated Priority List submissions. Going forward, USACOM will focus on effectively identifying, developing, experimenting with, and incorporating new information age ideas to enhance coherent joint operations. In the short to mid-term, this involves refining and integrating existing systems and organizations to support coherent joint operations that meet 21st-century challenges like interoperable combat identification, attack operations against critical mobile targets, and focused logistics. In the far term, experiments will explore revolutionary ideas and future technologies such as autonomous operations, biocentric operations, space operations, mastery of information, and global power projection. The Joint Experimentation Futures Program will establish a baseline for projections of the future security environment and will develop revolutionary ideas that support an aggressive approach toward the revolution in military affairs.

IDA and the Joint Advanced Warfighting Program (JAWP)

JAWP was initiated by the Under Secretary of Defense, Acquisition and Technology, and the Vice Chairman, Joint Chiefs of Staff, and located at IDA. Its focus is on development and experimentation addressing concepts and capabilities needed to underwrite the goals of *JV2010*. The JAWP's mission is to serve as catalyst for breakthrough changes in military capabilities by helping elaborate new concepts and capabilities, conducting joint experiments, integrating related activities, and preparing for implementation. The JAWP is participating in USACOM's Joint Experimentation Program.

The Joint Advanced Distributed Simulation Joint Test Force, Kirtland AFB, NM

The JADS/JTF was formed in 1994 in Albuquerque, NM, with the purpose of determining the utility of ADS for developmental and operational test and evaluation. The approach was to conduct three major tests: (1) a system integration test with flexible precision guided munitions (PGMs) test and evaluation (T&E) using advanced medium-range air-to-air missile (AMRAAM) and the advanced intercept missile (AIM-9M); (2) an end-to-end test with integrated C^4ISR T&E using JointSTARS; and (3) an electronic warfare test with an enhanced electronic warfare test process using ALQ-131.

The first phase of the System Integration Test linked simulators to hardware-in-the-loop laboratories and AIM-9M missiles. The second phase was a live-fly test with live aircraft, a hardware-in-the-loop missile laboratory, and AMRAAM. The results proved that ADS does have utility for integrated weapon and launch system T&E for closed-loop and open-loop interactions. Three benefits of ADS to PGMs were identified: cost savings, improved testing, and more efficient testing. Benefits included the replacement of some live shots with ADS; a higher live-fire success rate by identifying failures earlier; an increased force density by using laboratories and models; more realism than in analytical models or standalone labs; more efficient use of test time with analysts-in-the-loop; and reduction of risk for live shots through realistic but simulated test rehearsal. The JADS end-to-end test examined the utility of ADS in C^4ISR testing by introducing ADS into developmental and operational T&E of a system under test JointSTARS. It included laboratory developmental and operational testing, ADS integration onto an E-8C, and operational testing with a live E-8C. The results indicate that ADS has high utility for C^4ISR testing and that test environments can be transitioned to distributed training environments. Specific benefits are cost savings, affordable test assets, reproducible high-confidence test results, and high virtual sortie rates.

The Joint Combat Search and Rescue Joint Test Force

Data were received on the results of the JTF for JCSAR. JCSAR tests were conducted to locate and identify rescue targets during Green Flag 96-3, ASCIET 96, Alaska, Bosnia, and Woodland Cougar 97.

Surface-based C^4I and mission planning was completed during three Blue Flags (96-3, 97-2, and 98-2). Recovery operations were tested during field tests and during two virtual simulation exercises. The virtual test and training used T-1 lines to link the TACCSF with AAEWW, Space and Naval Warfare Systems Command, Air Combat Environment Test Evaluation Facility, and AVTB. The JCSAR concluded that the current JCSAR forces cannot consistently, rapidly, and accurately locate and identify survivors, process critical information quickly and error-free, or plan and execute effective missions in a timely manner. The major root causes include inadequate training in all phases of joint CSAR operations; inadequate systems or equipment for location, identification, and C^4I; and inadequate joint CSAR doctrine and procedures. The JCSAR virtual simulation exercises proved more suitable for training than testing. They provided similar results to field tests in interoperability problems noted, and aircrew participants were enthusiastic about the potential for training. The JCSAR legacy products include a virtual simulation architecture for USACOM, a JCSAR database and website for the Joint Combat Rescue Agency, and a JCSAR constructive simulation model for both joint and service applications. A primary conclusion from the JTF is that the CINCs and Services should provide realistic, joint, end-to-end CSAR training and use the virtual exercise concept to complement live exercise training.

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Chapter 10

Relevance

10.0 Study Recommendations Mapped to Global Engagement Operations

Tables 10-1 through 10-5 present the 19 major achievable recommendations in a Global Engagement Operations (GEO) context. Listed across the top of each matrix are our study recommendations. The rows of each matrix represent the phases of GEO and the next major level of indenture, the GEO elements. If a particular recommendation has relevance to a GEO element, an entry is shown at that intersection. The entry is the abbreviation for the study panel that proposed the recommendation. Additional detail on the recommendation can be found in that panel's chapter of this volume.

Table 10-1. *GEO Matrix, Shape Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Shape Phase																			
Maintain readiness, home defense, and deterrence through aerospace power	I&V LE	LE	I&V	LE	I&V		I&V		D&S		LE	LE	LE	LE		ETE	D&S	ETE	D&S LE
Enhance global awareness from air and space	I&V LE	LE	I&V		I&V		I&V								NLE			ETE	
Rely on air mobility to underwrite global presence and forward basing									D&S							ETE	D&S	ETE	D&S
Provide tailored aerospace expeditionary forces worldwide	I&V LE	I&V LE		LE	I&V	FM	I&V		D&S	NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	D&S LE
Deliberate planning and force structure requirements development **(new SAB recommended element)**	LE				I&V	FM		FM	D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE		ETE	
Train and exercise for all missions **(new SAB recommended element)**	LE	LE		LE	I&V				D&S	NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	LE

Table 10-2. *GEO Matrix, Deter Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Deter Phase																			
Focus aerospace intelligence, surveillance, and reconnaissance to conduct appropriate information operations	I&V LE	I&V LE	I&V	LE	I&V		I&V						NLE	NLE	NLE	ETE		ETE	
Conduct integrated crisis action planning **(new SAB recommended element)**	LE	LE				FM			D&S	NLE	NLE	NLE	NLE		NLE	ETE		ETE	
Strengthen the strategic air bridge	LE						I&V	FM	D&S				NLE			ETE	D&S	ETE	D&S
Respond rapidly with forward and home-based Aerospace Expeditionary Forces and arrive ready to execute the mission	I&V LE	I&V LE	I&V		I&V		I&V		D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	D&S LE
Employ dynamic command and control and agile logistics	LE					FM	I&V	FM	D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	

Table 10-3. *GEO Matrix, Halt Phase*

Elements	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Halt Phase																			
Exploit information operations	I&V LE	I&V	I&V		I&V		I&V	D&S	D&S				NLE		NLE			ETE	LE
Employ precise and decisive aerospace power	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	D&S LE
Master asymmetric strategies	I&V LE	I&V LE	I&V	LE			I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE			ETE	D&S LE
Sustain deployed forces **(new SAB recommended element)**	LE								D&S							ETE	D&S	ETE	D&S LE
Find, fix, track, target, and engage anything significant in near–real time and assess effects	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE		ETE	LE

Table 10-4. *GEO Matrix, Win Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Win Phase																			
Continue to counter adversary capabilities with precision	I&V LE	I&V LE	I&V	LE			I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE			ETE	LE
Hold at risk strategic, operational, and tactical targets	I&V LE	I&V LE	I&V	LE			I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE		ETE	LE
Enforce political, economic, and military sanctions with aerospace power	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	LE	NLE LE	NLE	NLE	ETE	D&S	ETE	D&S LE
Sustain deployed forces through agile combat support **(new SAB recommended element)**	LE							FM								ETE	D&S	ETE	D&S
Integrate aerospace forces into the combined counteroffensive	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	D&S LE

Table 10-5. *GEO Matrix, Reshape Phase*

	Enable Persistent ISR					**Develop and Integrate ISR and Dynamic Planning**				**Develop and Integrate Lethal/ Non-Lethal Weapons Effects**						**Enable Enduring Presence Within OPTEMPO Constraints**			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Reshape Phase																			
Enhance post-crisis stability with a skilled and motivated aircrew	LE								D&S	NLE					NLE	ETE	D&S	ETE	LE
Redeploy and reconstitute forces **(new SAB recommended element)**	LE					FM			D&S								D&S	ETE	D&S LE
Sustain heightened readiness to react decisively to a renewed crisis	I&V LE	I&V	I&V			FM	I&V		D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	D&S LE
Rely on agile combat support to react rapidly with Aerospace Expeditionary Forces	LE								D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	D&S LE
Maintain global and situational awareness	I&V LE	I&V	I&V				I&V								NLE			ETE	LE

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Chapter 11

Somalia Vignette 2010

(A Notional Scenario for the 1999 Air Force Scientific Advisory Board Summer Study)

11.0 Background

This vignette was developed from several possible future environments taken from the 1998 Joint Strategic Review. These projections are based on a continued emergence of a multipolar world (U.S. engagement, rogue powers, competitive economic blocks) and a resumption of a bipolar world (near-peer competitor). Its historic basis is a geo-strategic situation similar to conditions in the Horn of Africa in 1991–1993 but updated to represent possible challenges in 2010 that may be countered by effective use of technology.

The scenario is characterized by widespread suffering and mass migration caused by famine and drought. This human catastrophe is made worse by a primitive infrastructure and civil unrest in which an unstable regime is incapable of coordinating relief support or reducing the panic and casualties caused by ill-defined and competing factions. The United Nations (UN) has requested that concerned nations provide relief supplies and support to the numerous and uncoordinated relief organizations that have insufficient transportation, logistics, medical, and communication capabilities. Ongoing relief operations have almost totally stalled as more than a million refugees, indistinguishable opposing factions, and trapped foreign nationals have clogged all lines of communication and urban areas.

The United States has elected to lead a mutlinational support effort, although international contributions and capabilities are very limited. A lingering conflict in the Balkans that has accelerated the North Atlantic Treaty Organization– (NATO–) Islamic tension has politically restrained European participation and greatly reduced access throughout the Middle East, Suez Canal, and Red Sea. On the other hand, it has become evident that some factions are supported by state and nonstate actors, who are suspected of giving them access to biological and chemical weapons and 2010 commercial technology (communications, imagery, media, and cyberwar capability).

Threats include short-range surface-to-air missiles (SAMs), man portable air defense system (MANPADS) (with multispectrum acquisition capability), anti-aircraft artillery (AAA), light artillery, small arms, terrorism (including chemical and biological assault), and information warfare (IW).

Deteriorating conditions and increasing violence have led to “mission creep” and sequential involvement in the following types of smaller-scale conflicts and peace operations:

- Foreign humanitarian assistance
- Noncombatant evacuation (unopposed)
- Noncombatant evacuation (opposed)
- Humanitarian intervention
- Asymmetric terrorist attacks (cyber attack on U.S. and global economic systems)
- Asymmetric terrorist attacks (biomedical)
- Strike (nuclear, biological, chemical [NBC] counterproliferation)
- Follow-on peace operations
- Interpositional peacekeeping

11.1 Phases of Involvement

Phase 1: Foreign Humanitarian Assistance

Situation. The Horn of Africa is suffering through a third year of drought, and fighting between clans (uncontained owing to a total regime breakdown) has created a mass movement of refugees. The regional infrastructure is now in shambles, and disease is rampant. The UN requests the United States and other concerned nations to transport supplies and establish basic support for nongovernment organizations (NGOs) (air and ground transport, medical assistance, food, water, communications, and basic shelter). Following the U.S. agreement to become involved, Somalia is further flooded with well-intentioned NGOs, but their uncoordinated deliveries are seized by combatants because the NGOs are not able to identify and target those most in need. European allies can only provide token support, owing to the lingering crises in the Balkans and growing opposition to NATO by Islamic nations and terrorist groups.

Prompted by widespread media coverage, the United States deploys a small Joint Task Force (JTF) to establish communications and basic support for relief organizations. However, strategic and tactical airlift is greatly encumbered by restrictions on flying over North Africa and the Arabian peninsula and the inability to precisely deliver supplies to urban areas and stranded NGOs and noncombatants. Access to regional ports is limited and refugees, opposing clans, and criminal factions control all airfields. The only airfields open are small, unimproved airstrips.

Mission. Relieve suffering; transport food, water, and critical supplies to dislocated distribution points from distant locations; and provide basic communications to NGOs.

Operational Challenges. It is difficult to provide logistics support and establish ports of embarkation and debarkation in a region with nearly nonexistent infrastructure. Efforts must be coordinated among numerous international relief organizations with varied and nonstandard communications and medical and transportation equipment.

The JTF is confronted with widespread panic, extreme temperatures, scarce amounts of potable water; tracking mass migration of refugees, and delivering supplies to urban areas and relief and distribution points that are clogged by hundreds of thousands of refugees. The magnitude of the required support overloads the constrained airlift capability. Incomplete and inaccurate maps and charts complicate the identification and location of alternative landing sites. Airspace control of U.S., international, and NGO aircraft and helicopters is essentially nonexistent. Drought-induced dust in the atmosphere creates instrument meteorological conditions below 5,000 feet.

Friendly Forces. There is a total of 1,600 U.S. personnel, consisting of a JTF Headquarters (HQ), eight tanker airlift control elements, civil affairs, communications, military and security forces, civil engineers, medical, logistics, and intelligence personnel. Helicopters, airborne Special Operations Forces (SOF), and AC-130 gunships are also included.

Phase 2: Noncombatant Evacuation (unopposed)

Situation. Conditions have rapidly deteriorated. The threat of Islamic fundamentalist terrorists and general lawlessness causes supporting nations to direct an orderly evacuation of their citizens. Some relief organizations request evacuation of personnel. Escalating tensions between NATO and the newly formed Islamic Federation result in more access constraints throughout the region.

The USS *Ronald Reagan* carrier battle group (CVBG) has been requested by "more neutral" nations in the region to not enter the Red Sea, and hostile submarines patrolling the West Coast of Africa keep the CVBG out of the area. The UN and allies request U.S. intelligence support. The U.S. deploys an additional 900 personnel.

Mission. Identify, locate, communicate with, and extract U.S. nationals and selected citizens of allied nations.

Operational Challenges. The location of many foreign nationals is unknown. Foreign nationals in known urban locations are co-located with refugees and warring factions over widely dispersed area. Friendly and unfriendly local populations are extremely difficult to identify. The inability to locate citizens and contact relief organizations is growing because of internal migrations and jamming of commercial (and some military) communications. Transportation to pickup points is complicated by a lack of infrastructure and masses of refugees. Marine CV-22s assigned to the Marine Expeditionary Unit accompanying the Reagan CVBG are out of range without land-based air refueling. Inflight and ground visibility is causing accidents and slowing operations.

Friendly Forces. Additional personnel are being added to those described above, along with C-130 transports, V-22s, more helicopters (mostly UH-60s and a few Pave Low helicopters) and a Predator unmanned aerial vehicle (UAV) system.

Phase 3: Noncombatant Evacuation (opposed)

Situation. Orderly evacuation is impossible because of the increasing threat and the inability to marshal evacuees due to a lack of transportation, poor visibility, and the mass of refugees. A dozen foreign nationals have been killed by warring factions. The supposition is that Islamic terrorists are fomenting disorder.

The United States, with token NATO support, deploys combat forces to safeguard relief personnel and evacuate citizens. U.S. support increases by 4,500 personnel from the following capabilities: SOF helicopters, battle management, intelligence, surveillance, and reconnaissance (ISR) and fighter aircraft, and detachment of Bradley Fighting Vehicles. Two companies of the 1/75 Ranger battalion secure an isolated airstrip for the new JTF HQ, noncombatant evacuation operations (NEOs), and a security base; the plan is to relocate other deployed forces to this location and reposition the Rangers back to the continental United States (CONUS) for other contingency tasking.

Mission. Deploy and employ combat forces as required to secure the extraction of foreign nationals; avoid inflaming the conflict and increasing friendly and noncombatant casualties at all costs.

Operational Challenges. Lines of communication are insecure and there is difficulty in locating and giving direction to evacuees. Inflight control and visibility are severely degraded. Transfer areas and debarkation points are very limited because of the mix of refugees and combatants. The larger U.S. and Allied footprint requires significant logistic effort to support combat and flight operations. The environment is rapidly changing—disease is spreading, it is difficult to separate combatants from noncombatants in urban areas, and foreign nationals are trapped in urban locations, rapid surveillance is needed to identify collection points and threat locations, force protection of rescue assets is becoming increasingly complex (concern for small arms, MANPADS, and mobile lasers, and difficulty in neutralizing these threats with no collateral casualties). Concern is rising for terrorist actions at en route locations.

Friendly Forces. Additional personnel are added to the existing specialties deployed for NEOs. U.S. Army armor, Rangers, and infantry units are deployed along with Air Force fighter, tanker, and command and control (C^2) ISR platforms; additional airlift, gunship, SOF helicopters, UAVs, and transport aircraft are added. The total U.S. force now exceeds 7,000.

Phase 4: Humanitarian Intervention

Situation. Evacuation begins amid isolated but small attacks on security and transportation forces. There is growing concern for the safety of relief personnel and foreign citizens and an inability to discern refugees from combatants. Famine, disease, and increasing armed clashes have killed a million people or more. Doctors find unusual symptoms. The UN requests increased transportation of supplies and security forces in theater because food distribution is critical to reversing the escalating crisis and reducing panic and the massing of refugees in urban areas.

The United States deploys nearly 4,300 additional troops. Navy and Marine Corps forces are still constrained by diplomacy and range. The second airfield is "seized" by the 1/75th and elements of the 24th ID; some military computer systems (particularly at the Air Mobility Command [AMC] and en route locations) are attacked with deceptive information or temporarily shutdown. The attacks deny some services and accessibility to the Internet.

Mission. Continue to relieve suffering in the hostile environment.

Operational Challenges. Contaminated water sickens many relief workers and deployed military personnel. Fuel contamination at several deployed locations disables many vehicles and, at one airfield, shuts down operations. Distribution of food and relief supplies is reduced by nearly 65 percent. A backlog of supplies at arrival and distribution points creates havoc to schedules and erodes support plan efficiency. However, the flow of supplies and arms to combatants continues, enabling them to threaten ports, airfields, distribution points, and the security of relief personnel and deployed U.S. and allied forces. There is difficulty in identifying, locating, and targeting combatants and providing C^2 of the U.S. and allied effort. Intermittent jamming of navigation, targeting, and communications is increasing, probably due to outside support. Although AAA and SAMs are old, apparent modifications have limited the effectiveness of U.S. radar warning receiver and electronic countermeasures systems. Allies are particularly vulnerable.

Friendly Forces. No new weapons systems or capabilities have been added; the existing range of U.S. forces has increased by more than 4,000 personnel and equipment. The U.S. forces total 11,200.

Phase 5: Asymmetric Terrorist Attacks (Cyber Attack on U.S. and Global Economic Systems)

Situation. The most capable of the warring factions is opposed to UN and U.S. intervention. This faction is being supported from outside the country with weapons, money, and, most important, IW capability. Tanker airlift control element and JTF computer systems have been rendered inoperable for hours at a time. Ground fire directed at airfields and relief helicopter landing zones is traced to terrorists hacking into the JTF network (allowing them to learn air tasking order timing and routing). Reachback C^2 and intelligence facilities experience erasure and manipulation of critical files.

In the United States, HQ AMC Tanker Airlift Control Center experiences significant C^2 disruptions caused by computer system viruses that not only affect airlift to the theater but also impact the entire airlift system. Periodic disruptions of air traffic control facilities, police and fire departments, and businesses require the President to ensure the nation that all is being done to safeguard national security and normal peacetime activities. The United States deploys 4,000 additional troops to reinforce humanitarian and security forces.

Mission. Conduct information operations. Identify and counter cyber attacks.

Operational Challenges. Widespread disruption of communications within the region and to CONUS substantially reduces the ability to plan, schedule, and execute operations and weakens public support. All JTF communication, navigation aids, and C^2 networks have been severely degraded because they

depend on satellite communications. Limited access and increasingly capable threats reduce the deployment schedule. Communications and navigation systems experience meaconing, intrusion, jamming, and interference. The U.S. population is becoming increasingly discontent with interruptions of public services and the electronic infrastructure.

Friendly Forces. The majority of additional forces are ground troops, spread across support and Air Force weapons platforms. The total force is up to 15,200.

Phase 6: Asymetric Terrorist Attacks (Biomedical)

Situation. Periodic attacks on deployed facilities with sarin and various persistent and nonpersistent agents kill dozens of U.S. and allied personnel and substantially slow the flow of airlift. Sarin attacks on Wall Street, at Texas Stadium during a Cowboys-Vikings football game, at Charleston Air Force Base (AFB), and in Washington, DC, metro stations kill hundreds and sicken thousands. Although there are numerous claims of responsibility, intelligence connects two known terrorist groups that possess biochemical capabilities with supporting opposition factions in the Horn of Africa and the Balkans. Human intelligence (HUMINT) identifies the production of agents at several terrorist camps in the mountains in southern Central Asia and in Southwest Asia. The United States deploys another 3,400 troops as conditions permit.

Mission. Protect CONUS and deployed forces and relief personnel from biological and chemical attack; identify and counter the use of biological and chemical weapons.

Operational Challenges. Locate widely dispersed sources of biological and chemical weapons, destroying and neutralizing weapons or their delivery systems (particularly in urban areas). Remaining indigenous water supplies are now completely contaminated by chemical attacks, and many food stores must be destroyed. There is insufficient protective equipment and clothing for relief workers and allied forces. Word of chemical attacks causes refugees, relief workers, and deployed personnel to panic. Use of persistent chemicals near airfields substantially reduces airlift flow and the capability of airbase defense forces. Maintenance and offload of aircraft are exceptionally degraded because of the time required for washdown (chemical washracks are limited to major installations). An unexpected attack at Lajes shuts down throughput for 3 days, and the return of contaminated C-17 to Charleston AFB causes panic in the United States and halts East Coast C-17 operations for 2 days. The returning elements of the $1/75^{th}$ Ranger battalion are caught at the Lajes hanger without mission oriented protective posture gear, resulting in multiple casualties. Contract airlines refuse to support the operations for fear of chemicals and lack of protective gear.

Friendly Forces. An increase of 3,400 personnel plus equipment spread is among the deployed forces. U.S. forces total 18,600.

Phase 7: Strike (NBC Counterproliferation)

Situation. The United States launches strikes against five terrorist training camps strongly suspected of producing agents used in Africa and CONUS. Distances in excess of 1,000 nautical miles to several targets preclude the use of naval air and Tomahawk Land Attack Missiles, and few land bases are available in the immediate region. After strikes, the U.S. Executive Branch through its Ambassador to the UN vetoes UN censure but must react to worldwide opinion that the strikes escalate the African and lingering Balkans conflicts.

The U.S. Congress (and overwhelming public opinion) demands proof that the strikes were justified and successful, and they want assurance that the strikes will not generate retaliation; U.S. deployment increases with another 3,400 personnel.

Mission. Locate, fix, and destroy (and verify) chemical and biological weapons production and storage facilities.

Operational Challenges. Chemical and biological facilities are widely dispersed and in remote areas, some of which are underground in hardened and deeply buried sites. One site is in the outskirts of a Central Asian city. Locating and destroying or neutralizing weapons or their delivery systems in transit is difficult because the terrorists have taken many precautions and have used populated routes, conveyances, and production and storage facilities. Many ingress routes to target areas are diplomatically closed to U.S. military aircraft; lessons from the past dictate careful target planning and interagency cooperation.

Friendly Forces. The majority of the increase is in Air Force fighter units. The total deployed force now exceeds 22,000 personnel. CONUS-based strategic bombers are placed on alert.

Phase 8: Follow-on Peace Operations

Situation. HUMINT, communications intelligence, and electronic intelligence identify numerous terrorist cells and clan headquarters operating throughout the region, mostly in urban environments. The National Command Authority authorizes precision (including urban) attacks with strict rules of engagement to minimize collateral damage and casualties. Casualties among relief workers and security personnel are mounting. There is increased concern for the safety of foreign nationals still trapped in the region. The United States deploys another 1,500 personnel.

Mission. Remove last vestiges of terrorist support and anti-Western faction leadership, C^2, and major offensive capabilities. Prevent opposing clans from disrupting relief operations.

Operational Challenges. The United States must minimize collateral damage, identify combatants scattered among the refugees, prevent military facilities from being overrun by masses of starving refugees, and maintain the safety of relief workers and foreign nationals.

Friendly Forces. Army ground forces and support staff increase. U.S. forces total 23,500.

Phase 9: Interpositional Peacekeeping

Situation. The conflict ramps down as C^2 and the leadership of anti-Western clans is eliminated or rendered ineffective. Terrorist activity is also greatly diminished, but the threat of attacks using weapons of mass destruction is still considered real. Continued surges of refugees searching for food and water have become the major concern. Disposition of more than 100,000 bodies is a critical problem as disease threatens relief workers and security forces. The lowered threat allows greater civil affairs and engineering activity. There is a rapid influx of massive amounts of aid crucial to the survival of several million people. The United States deploys another 1,000 troops and begins unit rotations.

Mission. Keep warring factions separated, ensure continued delivery of relief supplies, stabilize the country, and establish conditions suitable for nation-building activities to begin.

Operational Challenges. The United States must keep warring and indistinguishable clan members separated, resume medical and relief support, and control disease. Nonexistent infrastructure and continued migration make ground transportation and patrols very difficult. Supply throughput by air and sea must sustain more than 100,000 U.S. and allied troops and the civilian population.

Friendly Forces. More forces are added, primarily in ground support personnel. The final U.S. force tally is 24,500.

Chapter 12

Southwest Asia Vignette 2010

(A Notional Scenario for the 1999 Air Force Scientific Advisory Board Summer Study)

12.0 Background

This vignette is a hypothetical scenario based on future conditions in joint guidance and unclassified sources including AF/XPX's Compendium of Concepts. This scenario was selected because it requires combat forces that must confront technologically sophisticated adversaries in an asymmetric environment. It features substantial weapons of mass destruction (WMD), information warfare (IW), and electro-magnetic pulse (EMP) conditions and aerospace tasks, such as long-range force projection, lethal and non-lethal precision attack, global awareness, and enhanced command, control, communications, and computers (C^4) intelligence, surveillance, and reconnaissance (ISR). This vignette includes the following smaller-scale conflict types: foreign humanitarian assistance (chemical, biological, and nuclear accidents), unopposed noncombatant evacuation operations (NEOs), opposed NEOs (hostage rescue), humanitarian intervention, maritime intercept operations, peacekeeping operations, and counterterrorism.

12.0.1 Geopolitical Assumptions

Regional

- The India-Pakistan border and ethnic conflict continues. Both sides possess capable armies and air forces equipped with modern Western and Chinese equipment. These nations have sophisticated computer industries, well-developed IW capabilities, and employment doctrine. Both nations have developed very capable theater ballistic missiles (TBMs) equipped with advanced nuclear and chemical-biological warheads. Taiwan, no longer an ally of the U.S., has been effectively neutralized by China.
- Korea is unified and has chosen to be neutral to avoid antagonizing China.
- A weakened Russia remains concerned about the emerging situation but is projected to become involved only if conflict spreads to the republics of the former Soviet Union.
- The southern republics of the former Soviet Union do not see this as their fight because terrorist groups in the disputed border area are not directly aligned with broader Islamic concerns.
- There has been no change in the status of Cambodia and Laos; Japan and Thailand remain in the U.S. camp, and the United States is still allied with Australia and New Zealand.
- The Philippines and Vietnam have moved closer to the United States since the Chinese took control of the Spratly and Paracel Islands in the South China Sea, established military outposts, and began exploiting the vast undersea oil reserves under the Spratly Islands. Bases and port facilities are accessible to U.S. forces.
- Following political upheaval, Singapore is now friendly with China; the Chinese navy and air force have access to Singapore's port facilities and military air bases.
- Internal religious strife is ongoing in Indonesia, which is no longer a major economic power.
- A network of separatist terrorists organizations has proliferated in the region, particularly in areas with significant Muslim populations.
- U.S. aircraft have been authorized to operate from bases in Oman, the Philippines, and Vietnam and from bases (to be determined) in India and Pakistan.

- China is approaching near-peer status and may be on a par with the U.S. in 10 years.
- U.S. military insights and advanced technology have been incorporated into Chinese weapons systems. As a result, several Chinese weapons are nearly as capable as their U.S. counterparts. Chinese intercontinental ballistic missiles are reliable, accurate, and equipped with state-of-the-art nuclear warheads.
- China possesses biochemical weapons that can be delivered by TBMs or cruise missiles.
- China has multi-intelligence satellites that are very capable.
- China obtained substantial technology from the United States in the 1990s.
- China's advances in information systems technology have given it the capability to project a wide spectrum of information operations threats.
- The Chinese "blue water" navy has warships and submarines equipped with up-to-date weaponry and is expanding its aircraft carrier capability.
- China possesses limited antiballistic missile and antisatellite capabilities.
- China's drive toward achieving hegemony since the turn of the century is proving successful; China is clearly the dominant power in Asia and influences all international geopolitical events in Asia and the Pacific.

Technological Assumptions and Threat

- Fourth-generation Soviet and Chinese front-line fighters are aggressively marketed in the region. Pakistan also has F-16s and many other systems obtained from the U.S.
- Asia was severely impacted by year 2000 problems. Following a long recovery, the region is now populated with advanced state-of-the-art computer hardware, software, and networks. As a result of the lessons learned from the year 2000 meltdown, extensive "firebreaks" were established in national networks to prevent the cascading effects of worldwide and regional network shutdowns caused by viruses.
- The growing worldwide demand on electromagnetic frequency spectrum bands has resulted in major problems and shortfalls. All available frequency bandwidths are used and are very costly to lease. Communications satellites (both geosynchronous and low earth orbit) are becoming marginalized as prime orbits become more crowded; bandwidth interference and "bleedover" is endemic as nations resort to increasing transmit power to maintain linkage with ground stations.
- Noncompliance with the policies and regulations of international frequency management organizations is increasing, especially in Asia.
- Fiber-optic C^4 lines are used extensively by military forces throughout Asia.
- Global Positioning System (GPS) and GLONAST navigation satellite networks are increasingly subject to compromise by ground-based jammers; GPS-guided smart weapons and aircraft navigation systems are increasingly susceptible to being "dumbed down."
- Ground-based laser systems capable of blinding aircrews have proliferated throughout the region.
- Third-generation surface-to-air missiles (SAMs) (SA-20, SA-22) and man portable air defense system using automatic target recognition, charged coupling devices, and Light Detection and Ranging guidance systems are available to air defense units in India, Pakistan, other major Asian nations. Stealth technology has become less of a sanctuary.
- Many terrorist groups possess biochemical weapons capability. Delivery systems are limited to ground vehicles, human delivery, and general aviation aircraft.

- Other threats to U.S. forces: During the early phases, U.S. aircraft are at risk from air defense forces (fighters and SAMs) of both sides and from radiation contamination in India. Muslim terrorists may target U.S. military ground personnel in both countries; neither government can guarantee their safety. IW has rendered regional commercial communications and navigation satellites useless. Chinese naval forces in the region must be considered a potentialthreat to any U.S. carrier battle group (CVBG) sent to the region and to U.S. aircraft. The potential is high for the situation to escalate beyond control and for the United States to become involved as a major combatant. During later phases, U.S. forces must contend with safety hazards caused by major disruptions in communications (including air traffic control) and satellite navigation as well as having to operate in radioactive and biologically contaminated environments.

12.1 Phases of Operation

(Note: This scenario is fictional, derived entirely from official sources and creative imagination; no classified information or sources were used.)

Phase 1: Noncombatant Evacuation

Situation. An accident involving a biological agent occurs in one of the terrorist camps located in the disputed transborder region of Kashmir, escalating the long-standing border dispute between India and Pakistan. The agent spreads to the surrounding area, causing numerous deaths and rampant sickness. In the face of growing outrage from the Pakistani public, Pakistani authorities charge complicity by Indian special forces in an attempt to cover up sponsorship of Muslim terrorists. India reacts strongly to the implication that its military was involved; tensions escalate between India and Pakistan, and both nations deploy substantial conventional forces along their border. Heeding U.S. State Department warnings, some U.S. citizens begin a voluntary evacuation from India and Pakistan, but fighting breaks out along the border and quickly escalates; both sides conduct limited airstrikes and conventional TBM attacks (selected Indian and Pakistani port facilities are hit with chemical and biological warheads). There are isolated terrorist acts and sabotage in both nations. Both sides engage in cyber warfare to gain strategic and tactical advantages. Numerous nations appeal for United Nations (UN) intervention in an attempt to resolve the crisis.

Mission. Evacuate U.S. citizens and selected foreign nationals in a potentially hostile and WMD environment.

Operational Challenges. The U.S. must conduct NEOs in a (chemical and biological) WMD environment with potential for nuclear escalation. Some operations may be conducted in radiologically or biologically contaminated environments. While neither combatant directly threatens U.S. citizens or forces, the potential for terrorist actions and spillover effects of combat exists for foreign nationals. Simultaneous NEOs in the two warring nations create substantial logistics and resource requirements. Many relief organizations are unwilling to support the crisis because of an inability to operate in WMD environments. Some request that the United States provide them this capability, and several nongovernment organizations already in theater have requested immediate assistance to evacuate or provide mission-oriented protective posture (MOPP) gear and other technological support. Neutral and friendly nations in surrounding areas are reluctant to make bases and ports available to U.S. airlift and support aircraft for fear of being drawn into the conflict and introducing nuclear contamination into their countries. Contract airlines refuse to allow aircraft into the immediate region without extensive U.S. technological support for operating in contaminated areas. Deployed forces, local authorities and relief organizations are unable to rely on commercial communications or GPS satellites covering South Asia.

U.S. Forces. Joint Task Force (JTF) Headquarters (HQ) (Oman), Air Force—ISR and battle management (RC-135, U-2, and Airborne Warning and Control System [AWACS]), two tanker airlift control elements

(TALCEs), combat communications units, one airbase defense flight, strategic and tactical airlift (C-17 and C-130J), and air refueling (KC-135R); Army—nuclear, biological, chemical (NBC) decontamination units (in country) and a portable field hospital (Oman); Special Operations Forces (SOF)—a Special Forces Group, Pave Low, and MC-130.

Phase 2: Foreign Humanitarian Assistance (Disaster Relief—Chemical and Biological), Humanitarian Intervention (Disaster Relief—Nuclear), Strikes (NBC Counterproliferation), Biomedical Terrorism, and Counterterrorism (Hostage Rescue)

Situation. Tensions escalate and fighting continues. The Pakistanis succeed in partially disabling the Indian electrical power grid computer network and cause widespread power outages. An Indian nuclear power plant near New Delhi experiences a meltdown as a result of computer sabotage. The resulting explosion and radioactive contamination spreads to parts of New Delhi, killing more than 10,000. Indian citizens are angered and call for revenge; fighting escalates. U.S. airlift aircraft are at risk from both Indian and Pakistani integrated air defense system (IADS). Meanwhile, terrorists take advantage of the fighting and stage attacks throughout India in reprisal for harsh measures previously taken by the Indian government against Muslims. In the disputed transborder region, terrorists have announced that they have recovered a TBM (and transporter-erector-launcher [TEL]) equipped with a WMD warhead (it is not known if the warhead is nuclear or biochemical). U.S. citizens are also being targeted by the terrorists; some have been killed, and a number have been kidnapped. Indian authorities are unable to cope with the spreading nuclear contamination. As the death toll mounts, India appeals directly to the United States and its allies for humanitarian assistance in dealing with the nuclear disaster. The most urgent need is to get the runaway nuclear reactor under control, but India and the UN are unable to develop a workable plan. They ask the United States to resolve the problem.

Mission. Provide humanitarian, medical, and technical assistance to Indian authorities to terminate the nuclear power plant meltdown and cope with massive casualties and decontamination efforts. Provide relief organizations the capability to operate in WMD environments. Locate, identify, and extract U.S. citizens kept hostage by terrorists in the disputed border region of Kashmir. Identify terrorist camps and support infrastructure. Be prepared to conduct counterproliferation strikes in India and Pakistan to prevent nuclear escalation. Identify, locate, and destroy, disable, or neutralize TBMs and TELs seized by the terrorists.

Operational Challenges. The rescue of hostages and strike operations must contend with extensive, state-of-the-art air defense systems in India and Pakistan. India and Pakistan are believed to have counterstealth technology. The location of many terrorist camps is known, but the sites with hostages or seized TBMs are only suspected although there have been intermittent communications intercepts. Humanitarian support to tens of thousands of local nationals has been complicated by disease caused by contaminated water and food sources and rapidly decaying bodies in extreme temperatures. Identification of all WMD agents that have been employed is required. MOPP gear is proving to be unwieldy and hazardous because of extreme temperatures, and it is only partially effective. Aircraft generation and airlift turnaround times have been extended significantly. Widespread panic in India threatens the logistics flow at airfields and ports. Indian authorities request that support be provided to urban areas away from airfields and ports to prevent massing of refugees and to ease the crisis. Most water supplies are contaminated. Electronic equipment in the New Delhi area is unreliable or has been disabled. Available beddown sites are very distant from the area of responsibility. Extensive air refueling is required because average sortie durations have been extended significantly. This problem increases maintenance demands and may lower readiness. Land-based tankers must also support naval air because ranges from CVBGs to the conflict area are well beyond F-18E and 18F range. U.S. forces require threat warning and protection from sea- and land-based SAMs and fighters, TBMs, and terrorist actions.

U.S. Forces. SOFs (Special Forces, the sea-air-land team [SEALs], CV-22, MC-130H, and other special units). Additional: Army—NBC units, medical teams, Military Police battalion, two civil affairs companies, a field hospital (India), Apache battalion, support helicopter battalion; Air Force—air operations center (AOC) (Oman), two air-transportable hospitals, four airbase defense flights, combat communications, F-117, F-22, F-16 (suppression of enemy air defenses [SEAD]); airborne laser (ABL), the Joint Surveillance, Target, and Attack Radar System (JointSTARS); SOF—additional Special Forces, and Pave Low helicopters.

Phase 3: Maritime Intercept Operations, Information Warfare

Situation. China follows the conflict closely, being careful to remain neutral. However, the Chinese view the impending U.S. humanitarian involvement with suspicion, which fuels U.S. concern for a potential conflict with China. Because of the growing tension between the United States and China, Chinese warships (including submarines) deploy to the Arabian Sea. Pakistani and Indian warships also patrol the surrounding waters and these nations demand that all incoming relief vessels be inspected for war materiel. The UN requests minimal U.S. Navy presence in adjacent waters to defuse rising tensions. Additionally, the seas are crowded with combatant and potentially combatant navies, which interfere with relief operations and cause substantial concern for U.S. naval operations. DoD tasks the Air Force to assist surveillance and to be prepared to interdict hostile sea power. The surrounding nations and the remaining U.S. allies in the Middle East and Southwest Asia become extremely concerned about the growing conflict, the spreading nuclear contamination, and the threat of a nuclear, chemical, or biological confrontation in the region.

Mission. Provide maritime support to naval operations; identify and neutralize the impact of IW on relief and military operations.

Operational Challenges. Multiple warships from many nations and numerous relief vessels must be identified and tracked. The effects of uncontrolled cyber warfare have thoroughly disrupted communications in the region (as well as theater-continental United States [CONUS] links), and the resulting lack of communications and guidance from national governments is causing widespread panic. Deployed U.S. command and control facilities are unable to provide uninterrupted C^4 to assets in the region. Communications with CONUS are also affected. Laser attacks on relief aircraft have caused several near accidents and two fatal crashes.

U.S. Forces. Navy CVBG and land-based maritime and anti-submarine warfare aircraft (EP-3, P-3); additional: Air Force—F-16 (multirole) and additional tankers, Rivet Joint, and AWACS; SOF—SEALs and the Fast Boat Unit.

Phase 4: Peace Accord Implementation and Follow-On Peace Operations

Situation. The UN Security Council, with concurrence of the United States and China, negotiates a cease fire between India and Pakistan and secures their approval to deploy a multinational peacekeeping force into the disputed transborder region.

Mission. The United States and some UN members deploy forces to conduct peacekeeping operations along the Pakistan-India border and in adjacent waters. Forces will remain to support a follow-on peacekeeping operation to restore stability between India and Pakistan.

Operational Challenges. The full WMD threat remains and humanitarian relief operations are ongoing amid widespread disease and suffering. U.S. forces must be prepared to change their mission orientation and swing rapidly between the UN-sponsored peacekeeping operation and actual combat.

U.S. Forces. Army—10th Mountain Division, additional—Air Force airlift, fighters (A-10), JointSTARS, and AWACS.

12.2 Key Aerospace Tasks

- Global mobility: Strategic and tactical airlift and multiple TALCEs to conduct inter- and intra-theater support of humanitarian relief, NEOs, disaster relief, and a large multinational peacekeeping operation. The United States must be able to:
  - Rapidly insert (air land and airdrop) and sustain a large, multinational ground peacekeeping operation
  - Precisely deliver supplies to deployed forces and host nation populations
  - Operate in contaminated airspace and turn at potentially contaminated beddown bases
  - Provide sufficient air refueling support for Air Force, Navy, and allied combat and support aircraft
- Force protection
  - AWACS and fighters to provide warning and protection for support aircraft
  - JointSTARS and ABL to detect and destroy TBM captured by terrorists
  - Airbase defense forces and capabilities to defend against infiltration, terrorist acts, hostile aircraft, and TBMs
  - Sufficient decontamination equipment, anti-exposure garments, and maintenance, support, and living facilities
  - Radar warning receiver, electronic countermeasures, jamming, and SEAD weapons to counter state-of-the-art IADS
  - EMP-resistant avionics, navigation, targeting, and flight control systems
  - NBC personnel and equipment to assist Indian authorities in shutting down the runaway nuclear power plant and containing the spread of radioactive contamination
  - Medical personnel to assist Indian authorities in treating thousands of people sickened and dying from radioactive contamination
- Global attack and lethal and non-lethal precision attack
  - Long-range precision weapons delivery
  - Countersea operations (interdict enemy sea power)
  - Air and ground SOF to conduct limited military operations (in a nuclear-contaminated environment) as needed against Muslim terrorists and to effect the release and rescue of U.S. hostages
  - Sufficient ground and air support forces to participate in a follow-on UN-sponsored peacekeeping operation
- Global awareness
  - Reconnaissance and surveillance to provide intelligence, targeting, and threat information to U.S. forces and allies
  - Reachback capability to CONUS (intelligence and nodal analysis and AOC) to reduce footprint in the potential WMD environment
  - Deployable communications capability to support operations

12.3 Required U.S. Forces

12.3.1 JTF HQ (from Pacific Command)

Air Force

50 C-17s, 50 C-5s, 50 C-130Js, 75 KC-10s, 75 KC-135Rs

Three E-3 AWACS, three E-8 JointSTARS, three RC-135V/W Rivet Joint

Five U-2s and RQ-4 Global Hawks, AL-1A Attack Laser (ABL)

48 F-22s, 36 A-10s, 36 F-16 SEADs, 48 F-16 multiroles

AOC, TALCEs, combat communications units

Army

NBC decontamination units, portable field hospitals, and civil affairs and psychological operations units

10th Mountain Division

SOF

CV-22, MC-130H, Pave Low, SEALs, special forces, special air units, special mission units, and a special boat unit

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Appendix A to Volume 2
Terms of Reference

USAF Scientific Advisory Board 1998 Study on
Technology Options to Leverage Aerospace Power in Other Than Conventional War Situations

BACKGROUND: In the 21st century as in the past, the nation will continue to rely on the Air Force to be ready to fight and win historically conventional conflicts, such as Desert Storm. This will compel the composition of the major portion of our force structure. As evidenced by the decade of the 1990s, though, the country will increasingly be involved in less-traditional situations and conflicts, such as those in Bosnia, Kosovo, and others. We will need to be able to prevent the employment of weapons of mass destruction, forestall adversary actions against civilians, operate in urban areas occupied by many civilians, or accomplish any number of less-traditional missions. These operations will often include joint and coalition forces. Rules of engagement may be politically constrained. Success or failure will be known worldwide in real time. It is essential that the nation be able to rely upon the Air Force in all these situations, especially for the flexibility and responsiveness that aerospace power provides. Viewed in the context of the evolution into an expeditionary force structure, it will become increasingly essential that our ability to respond in these nontraditional situations not be limited to only one segment of the Aerospace Force. To ensure this, the Air Force must be able to use the full array of aerospace forces, to understand orders of battle for the varied environments in which we may be called upon to enter, and then to provide appropriate enabling actions to achieve theater commander objectives or pave the way for follow-on forces that may be necessary.

STUDY PRODUCTS: Briefing to SAF/OS and the Air Force Chief of Staff in October 1999. Publish report in December 1999.

CHARTER: In the near (2005), mid (2010) and far (2015) timeframes:

1. Review operations conducted in the past decade (Rwanda, Somalia, Kosovo, Bosnia, and others) and identify successes and limitations of force application where aerospace forces, as is or modified, could have improved outcomes.

2. Posit future situations or vignettes that are representative of "less-traditional" operations that the nation is likely to depend on the Air Force to support.

   - Identify the objectives and tasks to be performed
   - Assess the capability of the programmed Air Force force structure to accomplish the tasks within operational concepts
   - Identify deficiencies
   - Survey sister Services' capabilities and programs to see whether they mitigate deficiencies

3. Survey the technology options available and suggest the technologies that should be pursued.

   - For the near term emphasize those more in accord with current operational art
   - For the farther terms, highlight the scientific and technological trends
   - Note those which will be accordant with current Air Force force structure plans and those that may require accommodation in plans
   - Consider destructive and non-destructive methods, as well as lethal and non-lethal

4. Identify testing or demonstrations being planned or conducted necessary for testing the concepts and systems. Recommend appropriate Air Force involvement.

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Appendix B to Volume 2
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Appendix C to Volume 2

Acronyms and Abbreviations

µm	Micrometer
2-D	Two Dimensional
3-D	Three Dimensional
A/C	Aircraft
A/R	Air Refueling
AAA	Anti-Aircraft Artillery
ABAM	Air Base Assessment Module
ABIS	Advanced Battlespace Information System
ABL	Airborne Laser
AC^2ISRC	Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center
ACC	Air Combat Command
ACC/DO	ACC, Director of Air and Space Operations
ACC/DOOE	ACC, Exercises, Planning and Employment Branch
ACC/XODZ	ACC, Capabilities Development Division, Distributed Mission Training Branch
ACETEF	Air Combat Environment Test Evaluation Facility
ACOM	Atlantic Command
ACR	Advanced Concepts and Requirements
ACS	Agile Combat Support
ACTD	Advanced Concept Technology Demonstration
ADS	Advanced Distributed Simulation
ADVON	Advance-on-Ground
AEF	Aerospace Expeditionary Force
AET	Advanced Embedded Technology
AETC	Air Education and Training Command
AETC/TRSS	AETC, Training Command and Support Squadron
AEW	Air Expeditionary Wings
AEW	Airborne Early Warning
AF/CC	Air Force Chief of Staff
AF/IL	Air Force Deputy Chief of Staff, Installations and Logistics
AF/SC	Air Force Deputy Chief of Staff, Communications and Information
AF/XO	Air Force Deputy Chief of Staff, Air and Space Operations
AF/XOC	Air Force Directorate of Command and Control
AF/XON	Air Force Directorate of Nuclear and Counter-Proliferation
AF/XOR	Air Force Directorate of Operational Requirements
AF/XPX	Air Force Staff, Strategic Planning
AFAMS	Air Force Agency for Modeling and Simulation
AFB	Air Force Base
AFDD	Air Force Doctrine Document
AFEO	Air Force Experimentation Office
AFIWC	Air Force Information Warfare Center
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFOTEC/Det1	Air Force Operation Test and Evaluation Center-Detachment 1
AFRL	Air Force Research Laboratory
AFRL/HE	AFRL, Human Effectiveness Directorate
AFRL/HEA	AFRL, Human Effectiveness Directorate, Warfighter Training Research Division
AFROC	Air Force Requirements Oversight Council

AFSOC	Air Force Special Operations Command
AFSOF	Air Force Special Operations Forces
AGE	Aerospace Ground Equipment
AIA	Air Intelligence Agency
ALP	Advanced Logistics Program
AMBL	Air Mobility Battlelab
AMC	Air Mobility Command
AMP	Avionics Modernization Program
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AMWC	Air Mobility Warfare Center
AOA	Analysis of Alternatives
AOC	Air Operations Center
AOR	Area of Responsibility
APOD	Aerial Port of Debarkation
ARC	Air Reserve Component
ARS	Airborne Radar Study
ASC/YW	Aeronautical Systems Center, Training Systems Product Group
ASD	Assistant Secretary of Defense
ASOC	Assured Support to Operational Commanders
ASSAULTT	Automated Simulation System for Advance Unit-Level Team Training
ATC	Air Traffic Control
ATD	Advanced Technology Demonstration
ATL	Advanced Tactical Laser
ATO	Air Tasking Order
ATR	Automatic Target Recognition
AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
BFTT	Battle Force Tactical Training
BIDS	Biological Integrated Detection System
Blue Force	Allied Forces
BMC^2	Battle Management Command and Control
BPI	Boost Phase Intercept
BTR	Beacon Tracking Radar
C^2	Command and Control
C^2ISR	Command, Control, Intelligence, Surveillance, and Reconnaissance
C^3STARS	Command, Control, and Communications Simulation, Training, and Research System
C^4	Command, Control, Communications, and Computers
C^4I	Command, Control, Communications, Computers, and Intelligence
C^4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CAF	Combat Air Force
CAP	Combat Air Patrol
CAP	Crisis Action Planning
CAX	Computer Assisted Exercise
CB	Chemical and Biological
CBU	Cluster Bomb Unit
CBW	Chemical and Biological Warfare
CENTCOM	U.S. Central Command
CEP	Circular Error Probable
CGF	Composable Next Generation Force
CINC	Commander in Chief

CJCS	Chairman, Joint Chiefs of Staff
CLS	Contractor Logistic Support
CM	Collection Management
CM	Countermeasures
CMD	Cruise Missile Defense
C-MNS	Combat Mission Need Statement
CNN	Cable News Network
COA	Course of Action
COG	Center of Gravity
COIL	Chemical Oxygen Iodine Laser
COMACC	Commander, Air Combat Command
CONOPS	Concept of Operations
CONUS	Continental United States
COP	Common Operating Picture
COTS	Commercial off-the-Shelf
CRAF	Civil Reserve Air Fleet
CSAF	Chief of Staff, United States Air Force
CSAR	Combat Search and Rescue
CVBG	Carrier Battle Group
CW	Continuous Wave
CW	Conventional War
D&S	Deployment and Sustainment
DARO	Defense Airborne Reconnaissance Office
DARPA	Defense Advanced Research Projects Agency
DCAPES	Deliberate and Contingency Planning and Execution System
DE	Directed Energy
DE ATAC	Directed Energy Application to Tactical Air Combat
DGPS	Differential Global Positioning System
DIA	Defense Intelligence Agency
DIS	Distributed Interactive Simulation
DMRS	Distributed Mission Readiness System
DMT	Distributed Mission Training
DMT-A	Aircrew Distributed Mission Training
DoD	Department of Defense
DoE	Department of Energy
DSB	Defense Science Board
DT	Developmental Testing
DTED	Digital Terrain Elevation Database
DWC	Distributed Warfighting Center
EAF	Expeditionary Aerospace Force
ECCM	Electronic Counter Countermeasures
ECM	Electronic Countermeasures
EFX	Expeditionary Force Experiment
EMCON	Emanation Control
EMD	Engineering and Manufacturing Development
EMP	Electro-Magnetic Pulse
EO	Electro-Optical
EO/IR	Electro-Optical/Infrared
ESC	Electronic Systems Center
ETE	Experiments, Training and Exercises
EW	Electronic Warfare
FIA	Future Intelligence Architecture
FLIR	Forward Looking Infrared
FPGA	Field Programmable Gate Arrays
GCCS	Global Command and Control System
GCSS	Global Combat Support System

GDSS	Global Deployment Support System
GEO	Global Engagement Operations
GEO	Global Expeditionary Operations
GMTI	Ground Moving-Target Indicator
GOB	Ground Order of Battle
GOTS	Government off-the-Shelf
GPS	Global Positioning System
GPS/INS	Global Positioning System/Inertial Navigation System
GTACS	Ground Tactical Air Control System
HAF	Humanitarian Expeditionary Force
HE	Human Effectiveness
HEL	High-Energy Laser
HLA	High-Level Architecture
HPM	High-Power Microwaves
HQ	Headquarters
HRR	High-Resolution Radar
HSI	Human-System Interface
HUD	Head Up Display
HUMINT	Human Intelligence
HUMRO	Humanitarian Relief Operation
I&V	Intelligence and Vigilance
I&W	Indications and Warning
IADS	Integrated Air Defense System
IC^2S	Integrated C^2 System
ID	Identification
IDA	Institute for Defense Analysis
IDS	Integrated Defense System
IDS	Integrated Deployment System
IFF	Identification of Friend or Foe
IIMS	Integrated Information Modeling System
IMINT	Imagery Intelligence
IMS	Information Management System
INMARSAT	International Maritime Satellite
INS	Inertial Navigation System
INU	Inertial Navigation Unit
IO	Information Operations
IPE	Individual Protective Equipment
IPEC	Integrated Planning and Execution Capability
IPT	Integrated Product Team
IR	Infrared
IRCM	Infrared Countermeasures
ISR	Intelligence, Surveillance, and Reconnaissance
ITV	In-Transit Visibility
IW	Information Warfare
JADS	Joint Advanced Distributed Simulation
JAG	Judge Advocate General
JASA	Joint Aerospace SIGINT Architecture
JAWP	Joint Advanced Warfighting Program
JBC	Joint Battle Center
JBI	Joint Battlespace InfoSphere
JC^2WC	Joint Command and Control Warfare Center
JCRA	Joint Combat Rescue Agency
JCS	Joint Chiefs of Staff
JCSAR	Joint Combat Search and Rescue
JEFX	Joint Expeditionary Force Experiment
JET	Joint Exercise Team

JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JLP	Joint Logistics Planner
JMEM	Joint Munitions Effectiveness Manual
JMNS	Joint Mission Needs Statement
JNLWD	Joint Non-lethal Weapons Directorate
JNLWP	Joint Non-lethal Weapons Program
JointSTARS	Joint Surveillance, Target, and Attack Radar System
JOPES	Joint Operational Planning and Execution System
JORD	Joint Operational Requirements Document
JPT	JFACC Planning Tool
JROC	Joint Requirements Oversight Council
JSIMS	Joint Simulation System
JS-LIST	Joint-Service-Lightweight Integrated Suit Technology
JSRC	Joint Search and Rescue Center
JSSE	Joint Services SERE (Survival, Evasion, Resistance, Escape) Agency
JSSED	Joint Service Sensitive Equipment Decontamination
JTF	Joint Task Force
JTMDAO	Joint Theater Missile Defense Attack Operations
JTSST	Joint Training System Support Team
JV2010	*Joint Vision 2010*
JWFC	Joint War Fighting Center
km	Kilometer
kW	Kilowatt
LAIRCM	Large Aircraft Infrared Countermeasures
LAN	Local Area Network
LASSOS	Laser Application to Space Optical Systems
lb	Pound
LDHD	Low-Density, High-Demand
LEA	Law Enforcement Authority
LIDAR	Laser Imaging Detection and Ranging
LIMFAC	Limiting Factor
LOCAAS	Low-Cost Autonomous Attack System
LOGCAT	Logistician's Capability Assessment Toolkit
LROS	Laser Remote Optical Sensing
LST	Laser Spot Tracker
m	Meter
M&S	Modeling and Simulation
M2DART	Mobile, Modular Display for Advanced Research and Technology
MAGTF	Marine Air Ground Task Force
MAJCOM	Major Command
MALD	Miniature Air Launched Decoy
MANPADS	Man Portable Air Defense System
MAP	Mission Area Plan
MASINT	Measurements and Signals Intelligence
MATT	Multifunction Advanced Tactical Terminal
MAV	Micro Air Vehicle
MC	Mission Capable
MCE	Modular Control Equipment
MDS	
MEMS	Micro Electro-Mechanical Systems
MHE	Materiel Handling Equipment
MLS	Multilevel Security
Mm	Millimeter

MNS	Mission Need Statement
MOE	Measure of Effectiveness
MOOTW	Military Operations Other Than War
MOP	Measure of Performance
MOPP	Mission-Oriented Protective Posture
MOUT	Military Operations in Urban Terrain
MRC	Major Regional Conflict
ms	Millisecond
MTC	Mission Training Center
MTI	Moving-Target Indicator
MTT	Multitask Trainer
MTTP	Multi-Service Tactics, Techniques, and Procedures
MTW	Major Theater War
MURI	Multidisciplinary Research Program of the University Research Initiative
MWS	Major Weapon System
NAS	Naval Air Station
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological, Chemical
NCTR	Non Cooperative Target Recognition
Nd:YAG	Neodymium (Nd)Yttrium Aluminum Garnet (YAG)
NEO	Noncombatant Evacuation Operation
NGO	Nongovernment Organization
NGSL	Next-Generation Small Loaders
NIJ	National Institute of Justice
nm	Nanometer
NMD	National Missile Defense
NMS	National Military Strategy
NOSC	Network Operations Security Center
NRO	National Reconnaissance Office
NSWC	Naval Surface Warfare Center
NTK	Need-to-Know
O&M	Operations and Maintenance
OCONUS	Outside Continental United States
OneSAF	One Semi-Automated Force
OOTCW	Operations Other Than Conventional War
OPINTEL	Operational Intelligence
OPR	Office of Primary Responsibility
OPTEMPO	Operational Tempo
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Testing
PACAF	Pacific Air Forces
PDU	Protocol Data Unit
PE/S	Precision Employment and Strike
PEM	Program Element Monitor
PERSTEMPO	Personnel Tempo
PGM	Precision Guided Munitions
PJ	Pararescueman
P_k	Probability of Kill
PLS	Personnel Locator System
PME	Professional Military Education
POL	Petroleum, Oils, and Lubricants
POM	Program Objective Memorandum
PSYOP	Psychological Operations
QDR	Quadrennial Defense Review

R&D	Research and Development
R&M	Reliability and Maintainability
RCC	Regional Contingency Center
RDT&E	Research, Development, Test, and Evaluation
Red Force	Enemy Forces
RF	Radio Frequency
RJ	Rivet Joint
RLA	Rotary Launching Assembly
RMA	Revolution in Military Affairs
RNIP+	Ring Laser Gyro (RLG) Global Positioning System (GPS)
ROE	Rules of Engagement
RSP	Readiness Spares Package
RTIC	Real-Time Information in the Cockpit
RWR	Radar Warning Receiver
SA	Situational Awareness
SAB	Air Force Scientific Advisory Board
SAF	Semi-Automated Force
SAF/AQ	Assistant Secretary of the Air Force, Acquisition
SAM	Surface-to-Air Missile
SAR	Synthetic Aperture Radar
SEAD	Suppression of Enemy Air Defenses
SEAL	Sea-Air-Land Team
SIGINT	Signals Intelligence
SIT	System Integration Test
SOCOM	Southern Command
SOF	Special Operations Forces
SOW	Special Operations Wing
SPAWAR	Space and Naval Warfare Systems Command
SPO	System Program Office
SPOD	Sea Port of Debarkation
SSB	Small Smart Bomb
SSC	Small-Scale Contingency
STAR	Strategic Threat Assessment Report
STEP	Survey Tool for Employment Planning
STOW	Synthetic Theater of War
SWARF	Senior Warfighter Review
T&E	Test and Evaluation
TACCSF	Theater Air Command and Control Simulation Facility
TACS	Theater Air Control System
TALCE	Tanker Airlift Control Element
TAN	Threat Avoidance Navigation
TAV	Total Asset Visibility
TBM	Theater Ballistic Missile
TBMCS	Theater Battle Management Core System
TBMD	Theater Ballistic Missile Defense
TCMD	Transportable Erectable Launch System ???
TCP/IP	Transmission Control Protocol/Internet Protocol
TCPED	Tasking, Collection, Production, Evaluation, and Dissemination
TEL	Transporter-Erector-Launchers
TEMO	Training, Exercises, and Military Operations
TF/TA	Terrain Following/Terrain Avoidance
TIBS	Tactical Information Broadcast System
TLAP	Technology Options to Leverage Aerospace Power
TMD	Theater Missile Defense
TRADOC	U.S. Army Training and Doctrine Command

TTP	Tactics, Techniques, and Procedures
TWCF	Transportation Working Capital Fund
U.S.	United States
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Air Vehicle
UDP	User Datagram Protocol
UGS	Unattended Ground Sensors
UN	United Nations
USACOM	United States Atlantic Command
USAF	United Stated Air Force
USAFE	United States Air Forces in Europe
USC	United States Code
USD	Under Secretary of Defense
USD(A&T)	Undersecretary of Defense for Acquisition and Technology
USG	United States Government
USJFCOM	United States Joint Forces Command
USMC	United States Marine Corps
USN	United States Navy
USSOCOM	United States Special Operations Command
USSOUTHCOM	United States Southern Command
USTRANSCOM	U.S. Transportation Command
UTC	Unit Type Code
UTC-DT	Unit Type Code-Dynamic Tailoring
UWB	Ultra Wideband
V&V	Verification and Validation
VCJCS	Vice Chairman, Joint Chiefs of Staff
VV&A	Verification, Validation, and Accreditation
W/cm^2	Watts per Centimeter Squared
WHO	World Health Organization
WISSARD	What-If Simulations System for Advanced Research and Development
WMD	Weapons of Mass Destruction
WRM	War Readiness Materiel

Initial Distribution

Headquarters Air Force

SAF/OS	Secretary of the Air Force
AF/CC	Chief of Staff
AF/CV	Vice Chief of Staff
AF/CVA	Assistant Vice Chief of Staff
AF/HO	Historian
AF/ST	Chief Scientist
AF/SC	Communications and Information
AF/SG	Surgeon General
AF/SF	Security Forces
AF/TE	Test and Evaluation

Assistant Secretary of the Air Force

SAF/AQ	Assistant Secretary for Acquisition
SAF/AQ	Military Director, USAF Scientific Advisory Board
SAF/AQI	Information Dominance
SAF/AQL	Special Programs
SAF/AQP	Global Power
SAF/AQQ	Global Reach
SAF/AQR	Science, Technology and Engineering
SAF/AQS	Space and Nuclear Deterrence
SAF/AQX	Management Policy and Program Integration
SAF/MI	Assistant Secretary (Manpower, Reserve Affairs, Installations & Environment)
SAF/SN	Assistant Secretary (Space)
SAF/SX	Deputy Assistant Secretary (Space Plans and Policy)
AFPEO/AT	Air Force Program Executive Office for Airlift and Trainers
AFPEO/C2	Air Force Program Executive Office for Command and Control
AFPEO/FB	Air Force Program Executive Office for Fighter and Bomber Programs
AFPEO/LI	Air Force Program Executive Office for Logistics Information Systems
AFPEO/SP	Air Force Program Executive Office for Space
AFPEO/WP	Air Force Program Executive Office for Weapons

Deputy Chief of Staff, Air and Space Operations

AF/XO	DCS, Air and Space Operations
AF/XOC	Command and Control
AF/XOI	Intelligence, Surveillance, and Reconnaissance
AF/XOJ	Joint Matters
AF/XOO	Operations and Training
AF/XOP	EAF Implementation
AF/XOR	Operational Requirements

Deputy Chief of Staff, Installations and Logistics

AF/IL	DCS, Installations and Logistics
AF/ILX	Plans and Integration

Initial Distribution (continued)

Deputy Chief of Staff, Plans and Programs

AF/XP	DCS, Plans and Programs
AF/XPI	Information and Systems
AF/XPM	Manpower, Organization and Quality
AF/XPP	Programs
AF/XPX	Strategic Planning
AF/XPY	Analysis

Deputy Chief of Staff, Personnel

AF/DP	DCS, Personnel

Office of the Secretary of Defense

USD (A&T)	Under Secretary for Acquisition and Technology
USD (A&T)/DSB	Defense Science Board
DARPA	Defense Advanced Research Projects Agency
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
BMDO	Ballistic Missile Defense Organization

Other Air Force Organizations

AC2ISRC	Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center
ACC	Air Combat Command
– CC	- Commander, Air Combat Command
– 366th Wing	- 366th Wing at Mountain Home Air Force Base
AETC	Air Education and Training Command
– AU	- Air University
AFMC	Air Force Materiel Command
– CC	- Commander, Air Force Materiel Command
– EN	- Directorate of Engineering and Technical Management
– AFRL	- Air Force Research Laboratory
– SMC	- Space and Missile Systems Center
– ESC	- Electronic Systems Center
– – DIT	Technology Applications
– ASC	- Aeronautics Systems Center
– HSC	- Human Systems Center
– AFOSR	- Air Force Office of Scientific Research
AFOTEC	Air Force Operational Test and Evaluation Center
AFSAA	Air Force Studies and Analyses Agency
AFSOC	Air Force Special Operations Command
AFSPC	Air Force Space Command
AIA	Air Intelligence Agency
AMC	Air Mobility Command
NAIC	National Air Intelligence Center
NGB/CF	National Guard Bureau
PACAF	Pacific Air Forces
USAFA	U.S. Air Force Academy
USAFE	U.S. Air Forces in Europe

Initial Distribution (continued)

U.S. Army

ASB	Army Science Board
SAAL-ZA	Assistant Secretary of the Army for Acquisition, Logistics, and Technology

U.S. Navy

ASN (RDA)	Assistant Secretary of the Navy for Research, Development, and Acquisition
NRAC	Naval Research Advisory Committee
Naval Studies Board	

U.S. Marine Corps

DC/S (A)	Deputy Chief of Staff for Aviation

Joint Staff

JCS	Office of the Vice Chairman
J2	Intelligence
J3	Operations
J4	Logistics
J5	Strategic Plans and Policies
J6	Command, Control, Communications, and Computer Systems
J7	Operational Plans and Interoperability
J8	Force Structure, Resources and Assessment

Other

21st Air Force
33rd Fighter Wing
36th Special Reconnaissance Squadron
53rd WG/EW
58th Special Operations Wing
621 Air Mobility Operations Group
Aeronautical Systems Center, Training Systems Product Group
Aerospace Corporation
AFDC/DR
AF/XOCA
AF/XOOS, Special Operations Division
AF/XOOT
Air Armament Center
ACC/DOOE
ACC/XO
ACC/XODZ
ACC/XOT
Air Force Agency for Modeling and Simulation
Air Force Command and Control Battlelab
Air Force Command and Control Training and Innovation Group
Air Force Experimentation Office
Air Force Information Warfare Center
Air Force Operational Test and Evaluation Center Det-1
Air Force Research Laboratory
AFRL/DE, Directed Energy Directorate

Initial Distribution (continued)

Other (continued)

AFRL/EW, Electronic Warfare Directorate
AFRL/HEA
AFRL/HED, Directed Energy Bioeffects Division
AFRL/IF, Information Directorate
AFRL/MN, Munitions Directorate
Air, Land, Sea Application Center
Air Mobility Warfare Center
AMC/DOT
ANSER
Central Intelligence Agency
DARPA WISSARD Facility
Defense Intelligence Agency
Defense Logistics Agency
Defense Systems Management College
Department of State, Office of Foreign Disaster Assistance
Director of Military Support
Electronic Systems Center
Electronic Systems Center/DIT
EUCOM, Joint Operations Division
IDA/Joint Advanced Warfighting Program
Joint C^4ISR Battle Center
Joint Command and Control Warfare Center
Joint Non-Lethal Weapons Directorate
Joint Warfare Analysis Center
Joint Staff, J-4
  Deployment Division
  Logistics Information Systems Division
  Logistics Readiness Center
  Sustainability, Mobilization, Plans, Exercises
Joint Warfighting Center
JTF Joint Advanced Distributed Simulation
JTF Joint Combat Search and Rescue
MITRE
National Reconnaissance Office
National Security Agency
Naval Surface Warfare Center
Naval Sea Systems Command
Network Operations Security Center
Office of the Secretary of Defense, Legal
RAND
Red Horse
Sandia National Laboratory
Study Participants
Theater Air Command and Control Simulation Facility
United Nations, High Commission on Refugees
U.S. Army Training and Doctrine Command
U.S. Joint Forces Command, J6 and J9
U.S. Central Command
U.S. Pacific Command

Initial Distribution (continued)

Other (continued)

U.S. Southern Command
U.S. Space Command
U.S. Special Operations Command
U.S. Transportation Command

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ABSTRACT (Maximum 200 Words)

Technology Options to Leverage Aerospace Power in Operations Other Than Conventional War

The 1999 Air Force Scientific Advisory Board (SAB) Summer Study focused on potential future environments that may involve the Air Force in Operations Other Than Conventional Warfare (OOTCW). The SAB was asked to provide technology options that could leverage the application of aerospace power in such operations.

The outcome of the study was a set of technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment. The team was to look at concepts, ideas and technologies that would allow United States forces to prevail while minimizing the number of airmen and ground troops that would have to be put at risk in OOTCW.

The study considered the past and potential future OOTCW environments and considered operations from humanitarian relief (HUMRO), noncombatant evacuation (NEO), peacekeeping, and no-fly zone maintenance, through regional conflict. The upper range of operations for the study, regional conflict, was understood to be just short of the very significant level of conflict encountered in Kosovo. While the study did not in general emphasize the lower-intensity operations (HUMRO and NEO), it did become clear early on that such "peacetime" operations have significant operational tempo impacts. The study attempted to define these impacts and to offer mitigation ideas.

14. SUBJECT TERMS
Operations Other Than Conventional War (OOTCW), peacekeeping, intelligence, surveillance, reconnaissance, deployment, sustainment, non-lethal weapons, lethal weapons, command and control, force management, experiments, exercises, training

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